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SCIENCE ABSTRACTS.

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ERRATA.

Abstract No. 82, line 2 : *for* Phil. Mag. pp. 387–395, 1898, *read* Phil. Mag. 46. pp. 387–395 1898.

No. 98, line 2 : *for* J. C. Schedd, *read* J. C. Shedd.

No. 143, line 1 : *for* C. Dieterrici, *read* C. Dieterici.

No. 179, line 1 : *for* J. K. Sumec, *read* J. K. Sumee.

No. 242, line 3 : *for* 88 to 89 per cent. oxide of thorium, 20 per cent. oxide of cerium, *read* 98 to 99 per cent. oxide of thorium, 2 per cent. oxide of cerium.

No. 286, line 2 : *for* pp. 1014–1019, *read* pp. 1019–1023.

No. 892, line 5 : *for* with as many arms (3) as there are generators, and a corresponding number of contacts, *read* with 3 arms and as many contacts as there are generators.

,, line 2 from foot : *for* the voltmeters V_1 and V_2 are provided for greater sensitiveness, *read* the voltmeter V_1 is provided for greater sensitiveness, and V_2 is used for adjusting the E.M.F. of the incoming machine to the 'bus bar P.D.

No. 897, line 19 : *for* along at equal angles apart, *read* along it and at equal angles apart.

No. 1029, line 1 : *for* J. J. Borgman and A. A. Petrowsky, *read* I. I. Borgmann and A. A. Petrovsky.

No. 1085, line 5 from foot : *for* $2\pi\sqrt{\frac{18{\cdot}4\,e\,i}{v\,d\,m}}$ *read* $2\pi\sqrt{\frac{v\,d\,m}{0{\cdot}102\,\pi\,e\,i}}$

No. 1126, line 1 : *for* J. Kümmell, *read* G. Kümmell.

No. 1169, line 23 : *for* lineal electric force, *read* linear electric force.

No. 1200, line 1 : *for* A. v. Hemptinnes, *read* A. v. Hemptinne.

No. 1260 : for the diagram which appears on page 565, substitute that which appears below.

No. 1272, line 1 : *for* M. Leblane, *read* M. Leblanc.

No. 1318, line 1 : *for* Diffusive Connection, *read* Diffusive Convection.

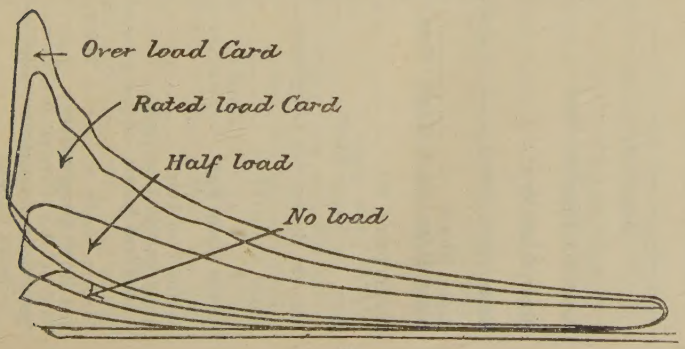
No. 1494, p. 669, line 15 : *for* brass gauges, *read* brass gauzes.

No. 1501, line 1 : *for* I. I. Borgman and A. A. Petrowski, *read* I. I. Borgmann and A. A. Petrovsky.

No. 1625, line 7 : *for* 5 mm., *read* 5 $\mu\mu$.

,, line 8: *for* 1 mm., *read* 1 $\mu\mu$.

No. 1873, line 9 : *for* gaslight, *read* gas-tight.



LIST OF JOURNALS.

In 1899 Abstracts were made from the following Journals. An asterisk (*) indicates that Abstracts were only occasionally made from those so marked.

Abbreviations.	Full Title.	Price.	Publishers, or Agents.
Acad. Sci. Cracovie, Bull.	Académie des Sciences de Cracovie, Bulletin	——	——
Amer. Acad. Proc.	American Academy of Arts and Sciences, Proceedings	——	American Academy of Arts and Sciences, 101–2, Beacon Street, Boston.
Amer. Assoc. Proc.....	American Association for the Advancement of Science, Proceedings	——	Amer. Assoc. for the Advancement of Science, Salem, Mass., U.S.A.
Amer. Electn.	American Electrician	Single copy, 10 cents ...	120, Liberty Street, New York.
Amer. Instit. Elect. Engin. Trans.	American Institute of Electrical Engineers, Transactions	Single copy, 50 cents ...	26, Cortlandt Street, New York City.
Amer. Journ. Sci.	American Journal of Science.....	$6.40 per ann., post free	Tuttle, Morehouse & Taylor, 125, Temple Street, New Haven, Connecticut, U.S.A.
Ann. Ass. Suisse Électr.	Annuaire de l'Association Suisse des Électriciens	——	J. Bollmann, Zurich, Switzerland
Ann. du Bureau des Longitudes...	Annuaire publié par le Bureau des Longitudes	——	——
Annal. Chim. Phys.	Annales de Chimie et de Physique	36 francs per annum.....	Gauthier-Villars, Quai des Grands-Augustins 55, Paris
Archiv Math. Phys.	Archiv der Mathematik und Physik, Leipzig	——	——
Archiv Post Tele.	Archiv für Post und Telegraphie	——	Published by the Reichs-Postamt, Berlin
Archives Néerlandaises.....	Archives Néerlandaises	16 fl. per volume	Martinus Nijhoff, La Haye, Holland
Astro-Phys. Journ.	Astro-Physical Journal	Single copy, 50 cents ...	W. Wesley & Son, 28, Essex Street, Strand, W.C.
*Astron. Nachr. & Beitr. z. Theor. d. Reversionspendels	——	——	——
*Atti del Acc. Givenia de Catane...	——	——	——
*Atti della Associazione Elettrotechnica Italiana	——	——	——
*Australian Mining Standard	——	——	——
Automotor Journal.....	Automotor and Horseless Vehicle Journal	Single copy, 6d.	F. King & Co., Ltd., 62, St. Martin's Lane, London, W.C.

Abbreviations.	Full Title.	Price.	Publishers, or Agents.
Berlin, Akad. Sitzber.	Sitzungsberichte der K. Preussischen Akademie der Wissenschaften, Berlin	12 marks per annum	Königliche Akademie der Wissenschaften, Berlin
Berlin, K. Tech. Versuch. Mitth.	Mittheilungen aus den Königlichen technischen Versuchanstalten zu Berlin	12 marks per annum	Julius Springer, N. 24, Monbijouplatz 3, Berlin
Berlin, Phys. Gesell. Verh. (changed to Verh. Deutsch. Phys. Gesell.)	Verhandlungen der Physikalischen Gesellschaft zu Berlin	—	J. A. Barth, Rossplatz 17, Leipzig
Bull. Ass. Ing. El. Liège	Bulletin de l'Association des Ingénieurs-Electriciens, Liège	Single copy, 6 francs	Gauthier-Villars, Quai des Grands Augustins 55, Paris
Bull. Soc. Belge Élect.	Bulletin de la Société Belge d'Électriciens	—	54, Rue Froissart, Brussels
*Bull. Soc. Chim.	—	—	—
*Bull. Soc. d'Encouragement	—	—	—
Cambridge Phil. Soc., Proc.	Cambridge Philosophical Society, Proceedings	Single copy, 2s. 6d.	C. J. Clay & Sons, Ave Maria Lane, E.C.
Cambridge Phil. Soc., Trans.	Cambridge Philosophical Society, Transactions	Single copy, 7s. 6d.	C. J. Clay & Sons, Ave Maria Lane, E.C.
Canad. Elect. News	Canadian Electrical News	Single copy, 10 cents	C. H. Mortimer Publishing Co., Ltd., Confederation Life Buildings, Toronto, Canada
Canad. Instit. Proc.	Proceedings of the Canadian Institute, Toronto	—	Arbuthnot Bros. & Co., Lombard Street, Toronto, Canada
Cassier	Cassier's Magazine	Single copy, 1s.	33, Bedford Street, Strand, London, W.C.
Chem. Met. Soc. of S. Africa, Journ.	Chemical and Metallurgical Society of S. Africa, Journal	—	—
Chem. News	Chemical News	Single copy, post free, 4½d.	E. J. Davey, 6 & 7, Creed Lane, Ludgate Hill, London, E.C.
*Chem. Zeitung.	—	—	—
Comptes Rendus	Comptes Rendus Hebdomadaires des Séances de l'Académie des Sciences	34 fr. per annum	Gauthier-Villars, Quai des Grands Augustins 55, Paris
Deutsche Zeitschr. Elektrotechn.	Deutsche Zeitschrift für Elektrotechnik	2 marks quarterly	Wilhelm Knapp, Halle a S., Germany
Dublin, Soc. Sci. Proc.	Scientific Proceedings of the Royal Dublin Society	—	Williams & Norgate, 14, Henrietta Street, Covent Garden, W.C.
Dublin, Soc. Sci. Trans.	Scientific Transactions of the Royal Dublin Society	—	Williams & Norgate, 14, Henrietta Street, Covent Garden, W.C.

LIST OF JOURNALS—*continued.*

ABBREVIATIONS.	FULL TITLE.	PRICE.	PUBLISHERS, OR AGENTS.
Écl. Électr.	L'Éclairage Électrique	60 fr. per ann., post free	G. Carré & C. Naud, 3, Rue Racine, Paris
Elect. Engin.	Electrical Engineer (London)	Single copy, 3d.	139 & 140, Salisbury Court, Fleet Street, E.C.
Elect. Engin. N.Y. (changed to Elect. World and Engineer)	Electrical Engineer (New York)	Single copy, 10 cents	120, Liberty Street, New York
Elect. Rev.	Electrical Review (London)	Single copy, 4d.	Alabaster, Gatehouse & Co., 4, Ludgate Hill, E.C.
Elect. Rev. N.Y.	Electrical Review (New York)	Single copy, 10 cents	Times Buildings, 41, Park Row, New York
Elect. World (changed to Elect. World and Engineer)	Electrical World	$6.00 per ann., post free	W. J. Johnston Co., 9, Murray Street, New York
Elect. World and Engineer	Electrical World and Engineer	Single copy, 10 cents	A. C. Shaw, Hastings House, Norfolk Street, Strand, London, W.C.
Electrician	The Electrician	Single copy, 6½d., post free	Salisbury Court, Fleet Street, London, E.C.
Électricien	L'Électricien	Single copy, 50 centimes	L. de Soye et Fils, 18, Rue des Fossés-St.-Jacques, Paris
Electricity, N.Y.	Electricity (New York)	Single copy, 10 cents	136, Liberty Street, New York
Elekt. Runds.	Elektrotechnische Rundschau	8 marks per annum	10, Kaiserstrasse, Frankfurt a M., Germany
Elektrochem. Zeitschr.	Elektrochemische Zeitschrift	18 marks 40 pf. per ann.	M. Krayn, 86, Steglitzerstrasse, Berlin, W.
Elektrotechn. Zeitschr.	Elektrotechnische Zeitschrift	25s. per annum	J. Springer, N. 24, Monbijouplatz 3, Berlin
*Elettricista	Elettricista, Rome	12s. per annum	Corso d'Italia, Porta Pia, Rome
Elettricità, Milan	Elettricità (Milan)	Single copy, 25 centesimi	Via Cusani 11, Milano, Italy
Engineer	The Engineer	Single copy, post free, 6½d.	33, Norfolk Street, Strand, W.C.
Engineering	Engineering	Single copy, post free, 6½d.	35 & 36, Bedford Street, Strand, London, W.C.
Eng. Mag.	Engineering Magazine	Single copy, 1s.	222–225, Strand, London, W.C.
Eng. News	Engineering News	Single copy, 15 cents	220, Broadway, New York
Feilden	Feilden's Magazine	Single copy, 1s.	[E.C. Temple Chambers, Embankment, London,
Frank. Instit. Journ.	Journal of the Franklin Institute	Single copy, 50 cents	Franklin Institute, Philadelphia
Göttingen, Nachrichten	Nachrichten von der Königlichen Gesellschaft der Wissenschaften zu Göttingen	—	Lüder Horstmann, Göttingen, Germany
Ind. Élect.	L'Industrie Électrique	Single copy, 1 franc	A. Lahure, 9, Rue de Fleurus, Paris
Ind. Electrochim.	L'Industrie Électrochimique	Single copy, 60 centimes	H. Becker, 5, Rue Guy-Patin, Paris
Indus. and Iron	Industries and Iron	Single copy, post free, 4½d.	39 & 40, Shoe Lane, London, E.C.
Instit. Civ. Engin., Proc.	Proceedings of the Institution of Civil Engineers	—	Published by the Institution, Great George Street, London, S.W.

Abbreviations.	Full Title.	Price.	Publishers, or Agents.
Instit. Elect. Engin., Journ.	Journal of the Institution of Electrical Engineers	Varies from 1s. 6d. to 7s. 6d.	E. & F. N. Spon, 125, Strand, London, W.C.
Instit. Mech. Engin., Proc.	Proceedings of the Institution of Mechanical Engineers	——	Published by the Institution, Storey's Gate, St. James's Park, London, S.W.
Journ. Chem. Soc.	Journal of the Chemical Society	——	Gurney & Jackson, 1, Paternoster Row, E.C.
Journal of Electricity	Journal of Electricity (San Francisco)	Single copy, 10 cents	315, Cherry Street, San Francisco, Cal., U.S.A.
Journ. Phys. Chem.	Journal of Physical Chemistry	$4.00 per annum	Gay & Bird (for London), 22, Bedford Street, Strand, W.C.
Journ. Phys. Chim. Élem.	Journal de Physique, Chimie et Histoire Naturelle Élémentaires	10 francs per annum	A. Buguet, 43, Rue de la République, Rouen
Journ. de Physique	Journal de Physique	15 fr. per ann., post free	11, Rue Rataud, Paris
Journ. and Proc. of R. S., N. S. Wales	Journal and Proceedings of the Royal Society of New South Wales	——	5, Elizabeth Street, Sydney, New South Wales
Journ. Télégraph.	Journal Télégraphique	Single copy, 40 centimes	Berne, Switzerland
Lightning	Lightning	Single copy, 2d.	8, Bream's Buildings, Chancery Lane, W.C
Manchester, Lit. and Phil. Soc. Mem.	Manchester Literary and Philosophical Society, Memoirs	Single copy, 2s.	36, George Street, Manchester
Mech. Eng.	Mechanical Engineer	Single copy, 6d.	Scientific Publishing Co., Hodson's Court, Corporation Street, Manchester
*Mem. de la Soc. des Ing. civils de France	——	——	——
Moscou, Soc. Nat. Bull.	Bulletin de la Société Impériale des Naturalistes de Moscou	——	J. N. Kouchnereff & Co., Pimenowskaia, propre maison, Moscou
N. Cimento	Nuovo Cimento (Pisa)	18.00 lire per annum	P. Salvioni, Tipografia Pieraccini, Via de Monte 12, Pisa
Nature	Nature	Single copy, 6d.	Macmillan & Co., Ltd., St. Martin's Street, London, W.C.
Paris, Soc. Franç. Phys., Bull	Bulletin de la Société Française de Physique	——	Published by the Society 44, Rue de Rennes, Paris
Paris, Soc. Franç. Phys., Séances	Séances de la Société Française de Physique	——	Published by the Society (as above)

Abbreviations.	Full Title.	Price.	Publishers, or Agents.
Phil. Mag.	London, Edinburgh, and Dublin Philosophical Magazine	2s. 6d. per month, occasionally 5s.	Taylor & Francis, Red Lion Court, Fleet Street, E.C.
Phil. Trans.	Philosophical Transactions of the Royal Society of London	Varies for separate papers	Dulau & Co., 37, Soho Square, London, W.
Phys. Rev.	Physical Review	Single number, 50 cents	Macmillan & Co., Ltd., London and New York
Phys. Soc. Proc.	Physical Society of London, Proceedings	——	Taylor & Francis, Red Lion Court, Fleet Street, E.C.
Proc. Chem. Soc.	Proceedings of the Chemical Society	——	——
Proc. Eng. Club, Phil.	Proceedings of the Engineers' Club of Philadelphia	$2.00 per vol.	1122, Girard Street, Philadelphia
Railroad Gazette	Railroad Gazette	$6.08 per ann., post free	32, Park Place, New York
Railway World (changed to Tramway and Railway World)	Railway World	Single copy, 6d.	Amberley House, Norfolk Street, London, E.C.
Rev. de l'El. Berne	Revue de L'Électricité, Berne	——	——
Revue Scientif.	Revue Scientifique	Single copy, 60 centimes	T. F. Unwin, 11, Paternoster Square, E.C.
Rivista Scientifica	Rivista Scientifico Industriale	12 lire per annum	2, Lungarno della Zecca, Firenze, Italy
Roma, R. Accad. Lincei, Att^{i}	Atti della R. Accademia dei Lincei, Roma	——	Published by the Academy, Rome
Roy. Instit. Proc.	Royal Institution of Great Britain, Proceedings	——	Published by the Institution, 21, Albemarle Street, London, W.
Roy. Soc. Proc.	Proceedings of the Royal Society of London	Single copy, usually, 1s. 6d.	Dulau & Co., 37, Soho Square, London, W.
St. Pétersbourg, Acad. Sci. Bull.	Bulletin de l'Académie Impériale des Sciences de St. Pétersbourg	Single copy, 2 mrk. 50 pfg.	Published by the Academy
St. Pétersbourg, Acad. Sci. Mém.	Mémoires de l'Académie Impériale des Sciences, St. Pétersbourg	Single copy, 3 mrk.	Published by the Academy
Science	Science	Single copy, 15 cents	Macmillan & Co.,66,Fifth Avenue,New York
Scientific American	Scientific American	16s. 5d. per annum, post free	361, Broadway, New York
Scientific Australian	Scientific Australian	2s. 6d. per annum, post free	Turner & Henderson, 16–18, Hunter Street, Adelaide
Soc. Arts Journ.	Society of Arts Journal	Single copies, 6d.	19, John Street, Adelphi, London, W.C.
Soc. Chem. Ind. Journ.	Journal of the Society of Chemical Industry	30s. per annum	Published by the Society, 9, Bridge Street, Westminster, S.W.
Soc. Int. Élect., Bull.	Société Internationale des Électriciens, Bulletin	Single copy, 2.50 francs	Gauthier - Villars, Quai des Grands-Augustins 55, Paris

Abbreviations.	Full Title.	Price.	Publishers, or Agents.
Street Rly. Journ.	Street Railway Journal	Single copy, 50 cents ...	A. C. Shaw, Hastings House, Norfolk Street, Strand, W.C.
Street Rly. Rev.	Street Railway Review	Single copy, 30 cents ...	Windsor and Kenfield Publishing Co., Monon Building, Chicago
Tram. Rly. World	Tramway and Railway World	Single copy, 6d.	Amberley House, Norfolk Street, London, E.C.
Torino, R. Accad. Sci. Atti	Atti della R. Accademia delle Scienze di Torino	—	—
Torino, R. Accad. Sci. Mem.	Memorie della R. Accademia delle Scienze di Torino	—	—
Verh. Deutsch. Phys. Gesell.	Verhandlungen der Deutschen Physikalischen Gesellschaft	4 marks per annum	J. A. Barth, Rossplatz 17, Leipzig
West. Electn.	Western Electrican (Chicago)	Single copy, 10 cents	510, Marquette Buildings, Chicago
Wied. Annalen	Annalen der Physik und Chemie	36 marks per annum	J. A. Barth, Rossplatz 17, Leipzig
Wien. Akad. Sitzber.	Sitzungsberichte der Mathematisch-Naturwissenschaftlichen Classe der Kaiserlichen Akademie der Wissenschaften, Wien	—	Carol Gerold's Sohn, Barbaragasse 2, Vienna
Zeitschr. Elektrochemie	Zeitschrift für Elektrochemie	4 marks per quarter	Wilhelm Knapp, Halle a S., Germany
Zeitschr. Elektrotechn. Wien	Zeitschrift für Elektrotechnik (Wien)	30 fr. per ann., post free	1, Nibelungengasse 7, Vienna
Zeitschr. Instrumentenk.	Zeitschrift für Instrumentenkunde	20 marks per annum	J. Springer, N. 24, Monbijouplatz 3, Berlin
Zeitschr. Instrumentenk., Beib.	Beiblatt zur Zeitschrift für Instrumentenkunde		
Zeitschr. Phys. Chem.	Zeitschrift für physikalische Chemie	—	W. Engelmann, Leipzig

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SCIENCE ABSTRACTS.

PHYSICS AND ELECTRICAL ENGINEERING.

JANUARY 1899.

GENERAL PHYSICS.

1. *Length-Variation of Iron and Steel during Recalescence.* **G. E. Svedelius.** (Phil. Mag. 46. pp. 173–192, 1898.)—Summarised from the original Swedish, published in 1895. Bars of iron or steel 4 cm. long were placed between two jaws of porcelain, so arranged that their movements could be observed by means of a mirror and telescope. In this position the bars were heated up to 800°, and the change of length recorded as a function of the time photographically. At the same time the temperature was recorded by means of a thermocouple. A number of the photographs obtained are reproduced in the paper, and tables calculated from them given. The phenomena of recalescence observed confirm the observations of Barrett and Osmond, and anomalous changes of length were discovered which are closely associated with recalescence, but are too complex to admit of a useful abstract. The measurements were made on two kinds of iron, hardened and unhardened, and containing up to 1 per cent. carbon. R. A. L.

2. *Correction of Micrometers by Interference.* **M. Hamy.** (Comptes Rendus, 126. pp. 1772–1775, 1898.)—Describes a method of correcting micrometers by means of observations upon Newton's rings. The mean value of a turn of the screw expressed in red fringes may be obtained: on calculating the other intervals in terms of this mean turn of the screw, and comparing with the numbers found directly, the corrections of the screw are got, and it is easy to express these in seconds of arc.
J. J. S.

3. *Interference Measurement Apparatus.* **C. Pulfrich.** (Zeitschr. Instrumentenk. 18. pp. 261–267, 1898.)—A description is given of an apparatus which has resulted from an endeavour to modify the Abbe-Fizeau dilatometer so as to extend its use in various ways. J. J. S.

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4. *Maintenance of Pendulum Motion.* **G. Lippmann.** (Comptes Rendus, 127. pp. 15–18, 1898.)—When the motion of a pendulum is maintained by clockwork the duration of the oscillations is altered. All perturbation disappears if the motion is maintained by a series of instantaneous impulses, equal and alternately of opposite sign, impressed on the pendulum successively whilst ascending and descending. The pendulum may have any position at the moment of the impulsion, provided that it be the same for two successive impulsions. In this case these impulsions produce perturbations equal and of contrary sign whose sum is rigorously zero. It is good to produce the impulsions at the moment of passing through the position of equilibrium, the perturbations produced by each impulsion are then separately nothing, or infinitely small, and on alternating their signs their algebraic sum is made zero. The author discusses the principle of the method and its application to the maintenance of the geodesical pendulum. He also suggests that it might be applied in experiments for determining the mass of the earth.
J. J. S.

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5. *Maintenance of Pendulum Motion.* **A. Guillet.** (Comptes Rendus, 127. pp. 94–97, 1898.)—The author satisfies Lippmann's conditions for the maintenance of a pendulum without perturbation (See previous Abstract) by producing the impulsions by means of induction currents due to the closing and opening of an inducing circuit. The pendulum opens and closes the inducing circuit when it passes through the vertical in the two senses. The mechanism of the arrangement is described in the paper. The induction method reduces to a minimum the auxiliary mechanical appliances, which are always liable to get out of order; and the satisfactory working has been shown by a performance of four months constantly controlled. The equality of the periods of the free and maintained pendulum has been experimentally proved. J. J. S.

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6. *Oscillations of Balances.* **D. Mendeléeff.** (Roy. Soc. Proc. 63. pp. 454–459, 1898.)—The observations were made with balances by Ruprecht and Nemetz of Vienna, belonging to the Central Chamber of Weights and Measures at St. Petersburg.

Calling the difference between the amplitudes of two consecutive oscillations the decrement, it is found that the time of an oscillation and the decrement decrease with the amplitude, whilst an increase of load sometimes increases sometimes diminishes them. Both the time of an oscillation and the decrement are diminished by increasing the sensibility, they are considerably affected by friction at the knife edges, and to some extent by the horizontal cross-section of the load. T. E.

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7. *Disintegration of Incandescent Wires.* **W. Stewart.** (Wied. Annalen, 66. 1. pp. 88–91, 1898.)—The author has determined the disintegration of a glowing platinum or palladium wire in various media and under various pressures. He found that as disintegration goes on the rate of disintegration gradually decreases. It remains unaffected by the presence or absence of moisture, and by surrounding it with a brass tube connected to earth. As exhaustion is carried further, the disintegration of platinum diminishes, while that of palladium increases. In hydrogen, platinum is not disintegrated, even at a white heat, and palladium much less than in air at all events. In nitrogen the disintegration is very feeble. It is possible that the process of disintegration requires the presence of both oxygen and nitrogen. E. E. F.

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8. *Air Jets.* **L. Mach.** (Wien Akad. Sitzber. 106. pp. 1025–1074, 1897.)—The author studies the structure of jets of air issuing from an orifice under various pressures by the interference method and by the method of striæ. The chief phenomenon noticed is that the jet appears broken up longitudinally into a series of double cones with their apices touching each other. These are due to a set of waves analogous to the head waves of projectiles, produced at the orifice just as if the latter were part of a projectile in motion. These head waves are reflected along the jet as they would along a tube, the motion of the jet through the neighbouring air being too rapid to allow the waves to penetrate the "skin" of the jet The higher the pressure, the more pronounced is the occurrence of stationary longitudinal compression waves along the jet. These are not yet explained by theory. E. E. F.

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9. *Air Waves due to Projectiles.* **Obermayer.** (Abstract in Engineering, 66. pp. 191–195, 1898.)—A number of new photographs of flying bullets, obtained by the method of striæ, are reproduced. Nearly all show the hyperbolic head wave which indicates that the velocity of the bullet is greater than that of

sound. But they also show the persistence of the air cushion in front of the bullet, which accounts for its apparent explosive effect. E. E. F.

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10. *Spreading of Liquid Films.* **J. Stark.** (Wied. Annalen, 65. 2. pp. 287–305, 1898.)—A number of experiments are described illustrating the spreading of a liquid at the surface of two media, where the capillary tension of the surface between the latter is greater than the sum of those at the surface of the liquid and the two media. Soot particles are used to render the movement visible, and the separation of these at the surfaces against which the movement carries them, and the convective motion in the media, are described and explained. B. B. T.

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11. *Elasticity of Thick Masses.* **Ribière.** (Comptes Rendus, 126. pp. 1190–1192, 1898.)—A discussion is given of the resistance to mechanical forces exhibited by thick blocks or masses, such as walls, &c. J. J. S.

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12. *Fizeau's Researches.* **A. Cornu.** (Annuaire du Bureau des Longitudes, 1898, pp. C. 1–C. 40.)—An interesting *résumé* of Fizeau's optical and metrological work. A. D.

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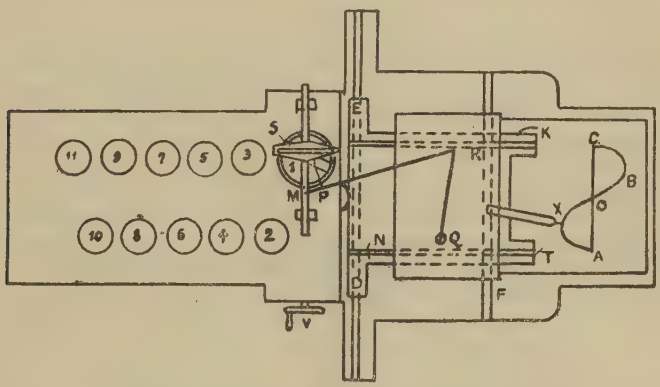
13. *Harmonic Analyser.* **J. N. Le Conte.** (Phys. Rev. 7. pp. 27–34, 1898.)—A harmonic analyser with eleven elements has been constructed at the University of California on the same fundamental principle as that of G. U. Yule's instrument made in 1895, the only difference being in the relative motion of the parts. The eleven axles (fig. 1) are connected by gearing in such a way that while the first revolves once, the second revolves twice, the third three times, and so on. Upon each axle is mounted a graduated circle, which may be turned through any epoch angle and clamped in any position. Across a diameter of each circle is a sliding bar, carrying a cylindrical pin, *s*, whose distance from the centre is adjusted by means of a graduated scale. Each pin works in the groove of a slotted cross-head, to which it communicates a simple harmonic motion when the whole is driven by the hand-wheel, *V*. *DK* is a flat platform of brass sliding along a pair of guides parallel to the direction of the harmonic motion of the cross-heads. Motion is communicated to it by a rack, so that while axle 1 rotates once, the platform moves through a distance 2π inches. Upon the upper face of

this platform is another pair of rectilinear guides, *LK* and *NT*, and upon these a light carriage runs on grooved wheels carrying a small planimeter board. The curve to be analysed is placed upon the base of the machine, and a point, *X*, attached to the carriage can be caused to trace round its perimeter. The accuracy of the instrument is said to be as great as that of most of the recent analysers. The instrument can also be used for drawing the curve whose coefficients are given up to the eleventh term, though no great accuracy is claimed for this process. When the instrument is arranged as a curve tracer, a grooved pulley is mounted upon each cross-head and a brass wire is passed around them all. The free end is attached to a light pen



carrier, which slides on a pair of tense wires at right angles to *DE*. A small weight takes up the slack of the wire, and the drawing paper is fastened to the platform *DK*. Amplitudes are set off on the sliding bars of the elements, and epoch angles on the graduated circles. A. S.

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14. *Optical Curve Tracer.* **J. A. Switzer.** (Phys. Rev. 7. pp. 83–92, 1898.)—The paper contains an account of the attempts made by the author to adapt the ingenious arrangement used by A. C. Crehore (see Phys. Soc. Abstracts, No. 652, 1895) for the measurement of the velocity of projectiles to the recording of alternating current curves. Briefly, the apparatus consists of a tube filled with carbon bi-sulphide, and surrounded by a coil conveying the current to be recorded. The light passing into the tube is polarised by a Nicol prism, and on emerging from the tube passes through a plate of quartz, a collimator, another Nicol prism, a dispersing prism, photographic lens and plate, the latter being allowed to fall by gravity when a record is taken. The function of the quartz plate is to produce an initial rotation of the plane of polarisation, and thus furnish a dark band in the

spectrum even when no current passes through the coil. Reproductions of photographic records obtained in this way accompany the paper. These are very poor, and seem to justify the author in his conclusion that the method is not likely to find any practical application. A. H.

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15. *Value of Gravity near Etna.* **A. Riccò.** (Roma R. Accad. Lincei Atti, 7. 2. pp. 3–14, 1898.)—The author, employing Sterneck's pendulum, determines the value of g at various points near Etna, and makes surmises with regard to the distribution of matter underground thereabouts. A. Gs.

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16. *Variations of Atmospheric Pressure.* **J. H. West.** (Wied. Annalen, 65. 4. pp. 943–950, 1898.)—The author uses an improved Hefner-Alteneck variometer, in which the tube communicating between the bottle and the atmosphere is stopped with a piece of matchwood instead of being drawn out to a point, thus preventing its being stopped up by moisture. Observations made during various kinds of weather show that the pressure of the atmosphere is never constant. Even when there is no perceptible wind, waves of pressure of periods varying from 5 to 30 minutes are recorded, and ripples of about a minute each.
E. E. F.

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17. *Photography of the Lunar Surface.* **Loewy** and **Puiseux.** (Ann. du Bureau des Longitudes, 1898, pp. A. 1–A. 36.) The authors first discuss the advantages of photographic as contrasted with ocular methods, and the difficulties inherent in photographic methods as applied to the lunar surface, arising from the necessity of giving a comparatively long exposure when fine detail is required in the image of a moving body; the air is also so far from uniform that during four years only ten nights have at Paris been found suited to lunar photographic work. The authors then proceed to discuss the problems to be solved, and the light thrown upon them by those good negatives which have actually been secured. An account is given of the changes which are supposed to have occurred on the moon's surface since detail markings were first studied; and the conclusion is reached that no change has occurred during the last half century such as causes any permanent modification of the general aspect of the moon, and that it is safer to ignore the past, as regards minor details, and start with the recent negatives, which show clearly the general grooving of the surface and the slight differences in colour between different portions of the surface. They also show, from the way the volcanic *débris* lies, that there must at one time have been a much denser atmosphere than

corresponds with the theoretical distribution of atmosphere between the earth and the moon, which would give the moon about $\frac{1}{729}$ of the whole. Probably the hydrogen was early lost, the other gases have been absorbed in chemical combination, and the water has sunk into the interior, to an extent no longer limited by internal heat as it is in the case of the earth. At present there is no surface liquid and no appreciable atmosphere, and there is no apparent trace of surface erosion by water. The surface also is that of bare rock, and there is no coating of ice in sight, not even at the poles, though it is not yet quite clear that there may not be some in the circumpolar depressions. The water vapour must have become rare before the surface cooled down to the temperature of condensation, and the water must have all, or nearly all, sunk in before the freezing-point was reached. On the earth the comparatively small surface has tended to prevent so rapid an escape of internal heat, and in the meantime the water is kept at and near the surface. A. D.

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18. *Stability of the Solar System.* **H. Poincaré.** (Ann. du Bureau des Longitudes, 1898, p. B16.)—The demonstrations of Lagrange, Laplace, and others, are successive approximations, showing in effect that the integral effect of disturbing causes is so small that it may be neglected, and that an approximately mean value is maintained amid an aggregate of slow oscillations of the elements of the planetary orbits. Poisson showed that the mean values are subject to slow oscillations round mean values which are still more approximately constant. Delaunay, Tisserand, and Gylden have shown that practically the same result follows in the case of commensurable mean motions. The result is that stability for a long time is proved, but not stability for ever. The demonstrations assume, however, that the planets are material points subject only to Newton's law of gravitation. But there are complementary forces, greater in their effect than the terms neglected in the demonstrations referred to. The law of the inverse squares need only be approximately valid in order to ensure the maintenance of stability. The entropy of the system, on the other hand, tends always to diminish, and does so upon the occurrence of each and every irreversible phenomenon, such as friction between the planets and the interstellar ether, or the pull-back by the tides upon the heavenly bodies whose motion gives rise to them, and whose kinetic energy is partly taken up in producing heat in the tidal water (Delaunay and G. Darwin) through friction retarding the tidal wave, introducing asymmetry and retarding the earth's rotation. We seem to have an instance of the effect of tidal action in the equality of the periods of rotation and of revolution of the moon. In the absence of any interstellar medium producing friction the ultimate effect of the tides would be to make the whole solar system rotate like a solid

body; but ether-friction would bring the planets gradually towards the sun. Even solid globes would show the same tidal effect in less degree, and the same end would be reached. The heavenly bodies if magnetic and conductors, like the earth, would also tend to slow down each other's relative motion; and even a frictionless vacuum would not prevent the same end being reached in time. A. D.

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19. *Solar Radiation.* **J. Janssen.** (Ann. du Bureau des Longitudes, 1898, pp. D. 1–D. 4.)—On Mont Blanc the solar constant was determined at between 3·23 and 3·26, but on specially clear days it was found to be 3·4, with some portions of curves giving 3·9. The value 3·4 is in the meantime that announced. A. D.

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20. *Magnetic Reproduction of Orbital Motion.* **R. W. Wood.** (Phys. Rev. 7. pp. 119–121, 1898.)—This note treats of a lecture experiment in which a steel bicycle ball rolls in a quasi-orbital manner on a glass plate under the influence of an electro-magnet below, whose pole-piece pierces the plate. The author has previously published this method, and now defends it against the criticism that the ball would be subject to an attractive force following the law of the inverse fifth power of the distance instead of the inverse square. The author points out that his critics have overlooked the fact that the ball is urged towards the centre by the horizontal component only of the attraction, and he finds that by suitably choosing the height of the plate above the pole-piece a position may be obtained for which within certain limits of distance the law is that of the inverse square. Several descriptions of an elliptical spiral may thus be realised and exhibited to an audience. E. H. B.

LIGHT.

21. *Infra-Red Absorption.* **H. Rubens** and **E. Aschkinass.** (Wied. Annalen, 64. 3. pp. 584–601, 1898.)—According to Langley, the infra-red solar spectrum terminates at 5 μ, the region beyond being absorbed by the atmospheric carbonic acid and water vapour. Since Rubens and Nicholls proved that beyond 24·4 μ a considerable amount of radiation is transmitted again by those gases, the authors sought these rays in the solar spectrum by their method of successive reflections. The result was negative, and further experiments proved that carbonic acid and water vapour do absorb those rays when present in layers of sufficient thickness. The atmosphere is perfectly opaque for rays from 12 to 20 μ and 24·4 μ. Langley's observations only extended to 11 μ. For meteorology this result is of slight importance, since the solar radiant energy beyond 12 μ is very small compared with the total energy. E. E. F.

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22. *Optical Properties of Hydrophane.* **J. Stscheglayew.** (Wied. Annalen, 65. 4. p. 745, 1898.)—The author acknowledges Christiansen's priority as regards his determination of the refraction index of hydrophane. (See 1898, Abstract No. 748.) E. E. F.

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23. *Rotatory Power of Quartz in the Infra-Red.* **R. Dongier.** (Comptes Rendus, 126. pp. 1627–1628, 1898.)—The author modifies the values he formerly gave (C. R. 125. p. 228), the wave-length of the radiations which he used having been calculated from M. Carvallo's results on the dispersion of quartz; these have now been more accurately obtained by M. Carvallo (C. R. 126. pp. 728–731; see 1898, Abstract No. 1120), hence the alteration of the author's numbers. J. J. S.

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24. *Fringes of High Order.* **C. Fabry** and **A. Perot.** (Comptes Rendus, 126. pp. 1561–1564, 1898.)—The authors have already made use of the fringes produced between two plane and parallel surfaces of silvered glass, illuminated by a beam of monochromatic light, for the study of the constitution of many rays of the spectrum. These fringes observed by transmission by means of a telescope have the aspect of concentric circles whose diameters follow the same law as those of Newton's rings. To a point of the field corresponds a definite incidence i,

and for that point the retardation which produces the interference is $\Delta = 2\,e\cos i$ (e being the distance between the two silvered planes). The fractional part of the quotient $p = \frac{\Delta}{\lambda} = 2\,e\cos i/\lambda$ is the difference of phase for the radiation λ, and the value of p is simply the retardation expressed in wave-lengths λ; each integral value of this quantity characterises a brilliant fringe of which it is the number of order. When the distance between the silvered surfaces is somewhat great, the number of order of the rings observed becomes very high ($p = 160{,}000$ for $e = 4$ cm. and $\lambda = 0{\cdot}5\,\mu$); the method employed for determining this number depends on the employment of many monochromatic radiations suitably chosen, of which the wave-lengths are in ratios exactly known. Suppose the apparatus is illuminated by two simple radiations, the one red and the other green, for example, of wave-lengths λ and λ' ($\lambda > \lambda'$). The rings due to these radiations will fall near each other without blending, on account of the presence of the brilliant fringes, and the rings of the two systems can be distinguished by their colours. If the distance between the silvered surfaces be caused to vary, these two systems contract or dilate simultaneously without the occurrence of movement of one system relatively to the other. A red ring of definite order will be always accompanied in the same manner by the same red and green rings which surround it. The fashion in which these rings present themselves will be characteristic of the red ring considered, and can serve as a means of its recognition. J. J. S.

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25. *Numbers of Order of Fringes.* **A. Perot** and **C. Fabry.** (Comptes Rendus, 126. pp. 1624–1626, 1898.)—The authors give a further account of the determination of the numbers of order of fringes, the principle of the method being based on the employment of a certain number of simple radiations suitably grouped two and two. (See previous Abstract.) They use for those measurements the red and green radiations of cadmium, employed by Michelson, and the yellow and green radiations of mercury. J. J. S.

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26. *Flicker Photometer.* **O. N. Rood.** (Science, 7. pp. 757–759, 1898.)—A description is given of a photometric method founded on flickers. The two sides of a white upright 90° prism are illuminated with the lights to be compared, and the flicker is brought about by the rapid motion of a cylindrical lens, or biprism of small angle placed opposite the angle of the white prism. The lens is caused to oscillate horizontally by a train of toothed wheels, turned by hand or by a small electromotor. By this means the two illuminated sides of the prism are presented

rapidly in succession to the eye placed beyond an aperture in front of the lens. Results of considerable accuracy were got even by persons unused to photometric work. J. J. S.

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27. *Colour-Blindness and the Flicker Photometer.* **O. N. Rood.** (Science, 7. pp. 785–786, 1898.)—The author describes the application of the flicker photometer to obtain a measurement of the relative extents of colour-blindness. J. J. S.

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28. *Flicker Photometer.* **F. P. Whitman.** (Science, 8. pp. 11–13, 1898.)—The author describes his experience with flicker photometers and corroborates Rood's statement (see 1899, Abstract No. 26) as to the ease with which the flicker photometer is handled by observers unaccustomed to its use. J. J. S.

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29. *New Photometric Standard.* **C. Fery.** (Comptes Rendus, 126. pp. 1192–1194, 1898.)—The author uses as a standard of light acetylene burning in free air at the extremity of a thermometer tube whose diameter is 0·5 mm. The intensity is proportional to the height of the flame, between 1 cm. and 2·5 cm. J. J. S.

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30. *Joly Colour-Photography Process.* **J. S. Gibson.** (Eng. News, 39. pp. 298–299, 1898.)—The Joly process is based on the fact that the eye is unable to differentiate colours lying within a certain area, termed by the author the "Retinal unit," and which does not exceed two or three minutes of arc. Consequently if the three primary components of a primary colour are placed side by side within the limits of this retinal unit, the area appears as of the composite colour. The process therefore differs in principle from Ives' in that the synthesis is effected by juxta- instead of super-position. The practical working is as follows: The light before falling on the photographic plate passes through a "taking screen." This is a gelatine-coated glass plate, ruled with tricolour bands (orange-red, yellowish-green, and blue), each colour-line being 1/225 in. broad. The light passing through this is split up into its three components arranged side by side in a space of 1/75 in., and the resulting negative consists of bands of silver deposit proportional in density to the intensity of the components of the colours. From this a positive is taken, in which the densities are reversed; on this is placed a "viewing screen" similar to the "taking screen" except that the colours are red, green, and violet. This, if correspondingly superposed, provides the component colours, which are regulated in intensity

by the density of the positive plate and are synthesised by the eye. The breadth of tricolour band required for perfect synthesis is about 1/400 in. at the ordinary range of vision, but 1/75 in. is found sufficiently narrow in practice. Exposure must be made through an orthochromatic screen (picric acid stain) on orthochromatic plates to obtain photographic equality in the colours.

G. H. Ba.

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31. *Coloured Photographs.* **L. Delvalez.** (Comptes Rendus, 127. pp. 207–208, 1898.)—A description is given of a method by which the author claims to get coloured photographs through the unequal lighting up of a brass plate placed as an extra electrode in an electrolytic bath containing a mixture of the acetates of copper and lead. J. J. S.

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32. *The Zeeman Phenomenon.* **H. Becquerel** and **H. Deslandres.** (Comptes Rendus, 126. pp. 997–1001, 1898.)—An account is given of the anomalous behaviour of certain rays, especially in the spectrum of iron, with respect to the Zeeman effect. Some rays are not doubled in the magnetic field, others become doublets, triplets, or quadruplets; the effects differing in the case of polarisation perpendicular to the field and polarisation parallel to the field. The anomalies show that the magnetic influence makes evident differences heretofore unknown between the rays of the same spectrum. J. J. S.

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33. *Zeeman Phenomenon.* **H. Becquerel** and **H. Deslandres.** (Comptes Rendus, 127. pp. 18–24, 1898.)—After describing their new experiments on the behaviour of different rays (especially those of iron) in very strong magnetic fields—up to 35,000 c.g.s. units—and arranging the various rays in classes according to their mode of division under the influence of the field, the authors seek for some general law of the doublings. They find that the doublings observed in the ultra-violet region are on the average notably smaller than those of the blue region. The phenomenon appears connected with a function of the wave-length which increases with that variable. If a region very limited and rich in rays be examined, anomalies and doublings the most diverse are met with there in the immediate neighbourhood of radiations insensible to the magnetic influence; classing the doublings in function of the wave-lengths of the corresponding rays, for the most part they may be ranged in different categories such that for rays of neighbouring wave-lengths the doublings are amongst themselves as the numbers 1, 2, 3, 4 . . . , and in the same category the doublings are

almost proportional to the square of the wave-length. The fact is specially noticeable for the greatest series of doublings, so that the modification that each ray of this series experiences due to the magnetic field would correspond to the same variation in the number of luminous vibrations emitted during the same time. For the rays which divide into fine bands the doublings of the radiations vibrating parallel or perpendicular to the field, are for the same ray exactly in the ratios of 1, 2, 3, 4. . . . The distribution of the doublings in the spectrum in function of the wave-length appears besides to affect a sort of periodicity. J. J. S.

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34. *Secondary Radiation.* **G. Sagnac.** (Comptes Rendus, 127. pp. 46–49, 1898.)—Further discussion showing that the "metal effect" is quite accounted for by the author's secondary rays (see 1898, Abstracts Nos. 245, 491, 765, and 1131). A. D.

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35. *New Radio-Active Element in Pitch Blende.* **P. Curie** and **Mme. Sklodowska-Curie.** (Comptes Rendus, 127. pp. 175–178, 1898.)—The suggestion that pitch blende contains some substance more active than uranium (see 1898, Abstract No. 1224) has been followed up and found to be true. It is present in the sulphides precipitated by sulphuretted hydrogen from an acid solution of pitch blende, and is so in company with lead, bismuth, copper, arsenic, and antimony. Sulphide of ammonium removes the arsenic and the antimony, nitric acid dissolves the remaining sulphides, and sulphuric acid removes the lead; the sulphate of lead should be well washed with dilute sulphuric acid in order to recover the portion of the element sought for, which is carried down by the precipitate. There remains in solution the new element, with bismuth and copper: ammonia in excess precipitates the two former. No good method has been found for completely separating these by wet methods, but the two sulphides have different volatilities, and when sublimed in a vacuum tube condense at different parts of the tube. The ultimate product is a sulphide 400 times as active as uranium, and appears to be that of a new metal, analytically related to bismuth: name proposed, Polonium. There is, however, no characteristic ray in its spectrum; but this is the character of the spectra of uranium, thorium, and tantalum, which present merely innumerable very fine lines, difficult to recognise. A. D.

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36. *Conversion of Kathode Rays into Light.* **E. Wiedemann.** (Wied. Annalen, 66. 1. pp. 61–64, 1898.)—The alleged economy of luminescent or fluorescent sources of light is based upon the

fact that the maximum energy radiated by them lies in the visible spectrum, the infra-red rays being practically absent. But when the expenditure of energy necessary to produce this glow is considered, the economy is very small. The author determined the heating effect which accompanies luminescence by inserting a calorimeter vessel in a vacuum tube, leaving it open at the top, and painting its bulb with Balmain's luminous paint or with Sidot's blende. He found that only about 5 or 7 per cent. of the incident energy was converted into light, that being about the same ratio as in the incandescent lamp.

E. E. F.

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37. *Röntgen and Kathode Rays.* **J. von Geitler.** (Wied. Annalen, 66. 1. pp. 65–73, 1898.)—The author quotes a number of experiments to show that Röntgen rays are absolutely incapable of conveying a charge. They can equalise opposite charges, by rendering the air between them conducting, but they cannot, like kathode rays, convey an electric charge into the interior of a closed metallic vessel connected to earth, or out of such a vessel into the open air. E. E. F.

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38. *Corpuscular Theory of Röntgen Rays.* **B. Walter.** (Wied. Annalen, 66. 1. pp. 74–82, 1898.)—Instead of regarding Röntgen rays as intermittent waves, they may be regarded as discharged kathode particles. Then the absence of magnetic deflection would follow as a matter of course. They penetrate the walls of a tube with greater ease than kathode rays on account of the absence of electric charge. They are undoubtedly much smaller than the electro-chemical ions. That their absorption should vary as the density of the absorbent is easily understood. Their power of ionising gases must be attributed to the destruction caused by their impact upon gaseous molecules.

E. E. F.

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39. *Glow-Discharge Spectra.* **A. Kalähne.** (Wied. Annalen, 65. 4. pp. 815–848, 1898.)—Using a battery of 600 cells, the author examined the continuous-current glow spectra of mercury, zinc, cadmium, sodium, and other vapours. He found that all these metals, like the metalloids, yield band spectra of inferior orders. Such band spectra may also be produced with the aid of an induction-coil, but in that case the band spectrum is faint in comparison with the line spectrum, the former being characteristic of lower temperatures. The correspondence between radiation and current strength, observed by Ångström in the case of nitrogen and hydrogen, does not apply to cadmium or mercury vapour. In the case of cadmium the intensity of the lines increases more rapidly, and in the case of mercury less rapidly than the current strength. E. E. F.

40. *Luminosity of Spectra of Gases.* **E. S. Ferry.** (Phys. Rev. 7. pp. 1–9, 1898.)—I. With gas pressure of from 0·25 mm. to 4·00 mm. of mercury, and current strengths from 1 milliampere to 6 milliamperes, the luminosity of the separate spectral lines of gases at a given pressure is directly proportional to the current strength. II. With constant current, the luminosity of a spectral line of a gas increases as the pressure decreases, at first slowly and then more rapidly. The curve showing the relation between the pressure of the gas and the luminosity of a spectral line is regular, but is different for different lines. G. B. M.

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41. *Radiation from Incandescent Gas Mantles.* **H. Le Chatelier** and **O. Boudouard.** (Comptes Rendus, 126. pp. 1861–1864, 1898.)—Luminescence is unnecessary as a means of explanation of the luminosity, and does not meet the case. The phenomenon is one of high temperature due to the material of the mantle being a bad radiator until a certain high temperature is attained. Heat therefore accumulates in the mantle until this temperature is reached. The effect depends only on the temperature attained, and not on the nature of the surrounding gases; this displaces Bunte's theory that catalytic action is the cause of the high temperature. The actual temperature is about 1650°. The proportion of radiation emitted in the form of light is very large; but the absolute amount of radiation in the form of light is less than it would be from a black substance at the same temperature. The difference is that the black substance under the same conditions would, through premature radiation, not reach the same temperature, and would therefore emit comparatively little light. A. D.

HEAT.

42. *Specific Heats of the Elements.* **W. A. Tilden.** (Chem. News, 78. pp. 16–18, 1898.)—In order to decide whether the atomic heats of the elements are identical, the specific heats of three pairs of carefully purified metals of nearly the same atomic weights are determined. The following are the mean results :—

Metal.	Specific Heat.	Atomic Heat.	Metal.	Specific Heat.	Atomic Heat.
Cobalt	0·10348		Nickel	0·10931	
Gold	0·03035	5·94	Platinum	0·03147	6·05
Copper	0·09232	5·83	Iron	0·11030	6·13

The atomic weights of cobalt and nickel being practically identical, their specific heats should be so likewise. The author suggests that the cause of the difference is to be sought in peculiarities in the configuration of the atoms of the metals.

T. E.

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43. *Specific Heat of Gases.* **S. Lussana.** (N. Cimento, 7. pp. 61–62, and 365–376, 1898.)—(i.) Experiments made by Lussana tend to confirm Amagat's law, according to which "the specific heat at constant pressure, referred to unit mass, of carbonic anhydride increases rapidly with the pressure, reaches a maximum at about 110 atmospheres and then diminishes, at any rate up to 150 atmospheres, the limit of pressure reached in the author's observations." This maximum tends to disappear with increase of temperature. In experimenting with mixtures of air and carbonic anhydride, it is found that, as the proportion of air is increased, the maximum observed in the carbonic anhydride for the values of C_p at about 110 atmospheres, tends to disappear and becomes non-existent when the proportion of air is sufficiently great. Experiments on acetylene had to be discontinued on account of its explosive character. (ii.) In the second paper new experiments relating to air are described, the methods of determining C_p at various pressures being radically changed. The first series of experiments shows that the mean variation of C_p per atmosphere is about 0·00111 ; the second to confirm the empirical formula $C_p = 0{\cdot}23702 + 0{\cdot}0015504\,(p-1) - 0{\cdot}0000019591\,(p-1)^2$. Comparing the results with those of Amagat and Witkowski, it is legitimate to infer that the specific heat of gases at constant pressure referred to unit mass increases with the pressure, attains

a maximum, and then decreases, that for air it is represented by the above formula, and that, moreover, it varies with the temperature. (For the previous paper see 1898, Abstract No. 129.)

G. H. Br.

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44. *Specific Heats of Gases.* **O. Lummer** and **E. Pringsheim.** (Wied. Annalen, 64. 3. pp. 555–583, 1898.)—This is a somewhat enlarged report of the experiments already described at the Oxford meeting of the British Association. The bolometer has been improved and the errors due to conduction of heat have been eliminated. The ratio of the two specific heats is for—

Air	1·4004
Oxygen	1·3977
Carbonic Acid	1·2995
Hydrogen	1·4084

E. E. F.

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45. *Latent Heat of Evaporation of Zinc and Cadmium.* **W. Sutherland.** (Phil. Mag. 46. pp. 345-346, 1898.)—Barus has given measurements of the vapour pressure curves for zinc and cadmium (Phil. Mag. (5) 29). From these the author calculates by means of the well-known thermodynamic equation that the molecular internal latent heats are 27,000 and 28,000 respectively for volatilisation of the solid metals under atmospheric pressure. Theoretical reasoning of his own gave 29,600 for each (Phil. Mag. (5) 40). R. A. L.

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46. *Surfusion of Metals and Alloys.* **W. C. Roberts-Austen.** (Roy. Soc. Proc. 63. pp. 447–454, 1898.)—By means of the photographic recording thermo-element, the phenomenon of surfusion is shown to occur with gold, copper, bismuth, antimony, tin, and lead. Reproductions of several of the curves are given in the paper. Surfusion is also observed with alloys, but the curves are more complicated owing to the formation of super-saturated solutions. The alloys of tin and lead are fully studied from this point of view. It is suggested that the extreme instability of metals in a state of surfusion may be due to the introduction of crystalline nuclei from the metallic vapour given off. An appreciable quantity of vapour is evolved by metals even at low temperatures. Silver and cadmium placed at some distance apart in a vacuous tube at 50° yielded a coloured film of silver cadmium alloy on the silver after eight days. T. E.

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47. *Influence of Pressure on Melting-Point.* **E. Mack.** (Comptes Rendus, 127. pp. 361–364, 1898.)—Certain organic

solids were melted in a dilatometer capable of standing pressures up to 2,140 atmospheres, provided with a piston manometer. Naphthalene was found to have a melting-point t under pressure p given by

$$t = 79{\cdot}8 + 0{\cdot}0373\,p - 0{\cdot}0000019\,p^2$$

while α-naphthylamine, diphenylamine, and paratoluidine gave still more nearly linera results. R. A. L.

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48. *Measurement of Temperature.* (Mech. Eng. 2. pp. 149–151, 219–221, and 258–259, 1898.)—Articles dealing with the various methods of temperature measurements. EDITOR.

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49. *Thermo-Electric Pyrometry.* **A. Stansfield.** (Phil. Mag. 46. pp. 59–82, 1898.)—The thermo-couples employed consist of a wire of platinum and another of platinum alloyed with 10 per cent. of Rhodium or Iridium; one junction being at 100° C. and the other at the temperature to be measured. The E.M.F. of the thermo-couple is recorded photographically by a method which combines the use of a potentiometer with the recording system of Roberts-Austen. Differences of temperature at 1000° C. can easily be measured in this way to 0.1° C., and the indications of the pyrometer do not change more than about 5° C. at temperatures of 1000° C. after a year's use.

The thermo-electric power of the couple composed of platinum and platinum alloyed with 10 per cent. of Iridium is a little greater than that of a thermo-couple containing 10 per cent. of Rhodium, but the *partial* substitution of Iridium for Rhodium in the latter couple very materially *reduces* the thermo-electric power.

The contact electromotive force $T\frac{d\,E}{d\,T}$ of these thermo-couples is approximately a linear function of the temperature. A table is given of the melting temperatures of certain metals as afforded by recent research. AUTHOR.

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50. *Absolute Temperature.* **O. Wiedeburg.** (Wied. Annalen, 65. 4. pp. 921–922, 1898.)—The author points out, in accordance with his previous work, that the anomalous position of the theory of heat among the theories of other forms of energy is eliminated by regarding a "falling quantity of heat" as a quantity in the same sense as a falling quantity of water or electricity. E. E. F.

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51. *Temperature of a Linear Conductor of Two Metals.* **P. Straneo.** (Roma R. Accad. Lincei Atti, 7. 2. pp. 346–353, 1898.)—The conductor consists of two bars of section q, and lengths l_1 l_2 taken for axis of x. It is traversed by a constant electric current i. The whole is initially at temperature zero, and the extremities are so maintained. Considering the Thomson and Peltier effects, and other known phenomena, the writer obtains differential equations which u_1 u_2, the temperatures of the two bars, have to satisfy. When the temperatures become stationary they are represented by U_1 U_2, and the differential equations then assume special forms for which integrals are obtained.

Finally, the special case is considered in which the greatest variations of temperature of the conductors are very small. In this case the differential equation assumes for the first bar the form—

$$U = \frac{i^2 \omega}{J q h p} + A_1 \varepsilon^{\lambda x} + B \varepsilon^{-\lambda x}$$

where ω is the ohmic resistance, h the external conductivity for heat, and p the perimeter, k the internal conductivity, and $\lambda = \sqrt{\frac{h p}{k q}}$. A and B are constants to be found by the terminal conditions. A further communication is promised. S. H. B.

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52. *Mechanical Equivalent of Heat.* **O. Reynolds** and **W. H. Moorby.** (Mem. Manchester Lit. & Phil. Soc. 42. 6. pp. 1–54, 1897–8.)—Water at 0° C. was forced at a steady rate through a vessel wherein it was churned so as to issue at 100° C., an internal stirrer being rotated by steam-power while the vessel was balanced by an external brake-dynamometer which measured the work absorbed. For details the paper must be referred to. The final result obtained is 776·94 in British gravitation-units at Manchester, which in C.G.S. absolute units gives 41,832,000, the heat-unit being the hundredth part of the heat required to raise 1 pound and 1 gramme respectively of water from 0° to 100° C. The method is due to the former of the authors, the experimental determination to the latter. R. E. B.

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53. *New Electro-Thermal Relation.* **O. Wiedeburg.** (Wied. Annalen, 66. 1. pp. 92–110, 1898.)—When the metals are arranged in the order of their power of emitting radiant heat, the series corresponds with their electrical resistances, although the ratios are not the same. An exception occurs in the case of nickel, whose radiating power is too small. Alloys do not fit into the series, but conform to a series of their own. Bismuth

is the best radiator, and silver the worst. The emissivity of bismuth is closely approached by a copper-manganese alloy containing 30 per cent. of manganese. E. E. F.

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54. *Bolometers.* **S. P. Langley.** (Amer. Journ. Sci. 5. pp. 241–245, 1898.)—The author describes the latest form of his bolometer, which is provided with a metal case kept at a constant temperature. It is also specially protected against earth tremors. As regards precision, or exactness of pointing, it can be set to within a second of circular arc in the dark. As regards accuracy, it is safe to say that no inaccuracy can be detected by comparing successive readings of a constant source. The apparatus is about 400 times as sensitive as when first described. It will indicate a change of temperature in its strips of much less than one-ten-millionth of one degree centigrade. E. E. F.

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55. *Absolute Actinometer.* **A. Crova.** (Comptes Rendus, 126. pp. 1394–1398, 1898.)—A description is given of the author's standard actinometer in which differences of temperature are measured by a thermo-electric arrangement. J. J. S.

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56. *Thermal and Electrical Conductivities of Iron and Copper.* **P. Straneo.** (Roma R. Accad. Lincei Atti, 7. 1. pp. 310–314, 1898.)—The changes in the thermal conductivities of copper and iron between 10° and 100° are small and cannot be determined with accuracy by the method employed, which is correct to only 1 per cent.

Simultaneous measurements of the electrical conductivities give the usual large increase with rise in temperature. A. Gs.

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57. *Transmission of Heat through Plates.* **G. Haliday.** (Indus. and Iron, 24. pp. 487–488. and 25. pp. 4–6, 1898.)—A paper read before the Institution of Engineers and Shipbuilders in Scotland, giving the leading known facts on the subject. The paper is illustrated by numerous diagrams and tables. A. S.

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58. *Propagation of Heat.* **G. Lauricella.** (Torino, R. Accad. Sci. Atti, 33. pp. 729–743, 1897–1898.)—This paper refers to a note by Stekloff (Comptes Rendus, April, 1898). Any arbitrary function which with its derivation of the first three orders is finite and continuous at all points within any body S, and which with its normal derivation is finite and continuous at all points on the bounding surface, can always be decomposed

into two functions, of which one represents the stationary temperature, which has no influence on the propagation of heat, and the other satisfies the limiting equations. Stekloff's demonstration of the existence of this latter function being not free from doubt, the following theorem is enunciated : "The variable temperature of a body initially given at any arbitrary temperature can always be regarded as the superposition on a stationary temperature of a finite or infinite number of elementary temperatures." S. H. B.

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59. *Theory of Liquids with Unassociated Molecules* (Part II.). **G. Bakker.** (Journ. de Physique, 7. pp. 511–515, 1898. Continued from vol. 6, p. 577, 1897 ; see 1898, Abstract No. 263.)—This paper, the reasoning of which does not well admit of an abstract, is a continuation of the author's previous speculations on molecular theory based chiefly on the virial theorem, and on certain assumptions of which the author admits the doubtfulness. His chief conclusion is that the virial of the molecular forces is equal to 3/2 the product of the internal pressure by the volume ; and he arrives at an opinion in favour of the inverse fourth power law as to molecular forces. R. A. L.

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60. *Density of Liquids and Saturated Vapours as a function of Temperature.* **C. del Lungo.** (Roma R. Accad. Lincei Atti, 7. 2. pp. 353–358, 1898.)—Let N be the number of molecules per unit of volume of a liquid in presence of its saturated vapour. Let ε be the velocity which is sufficient for a molecule arriving at the boundary to overcome the attraction of the liquid, and pass into the vapour. Let $\frac{n}{N}$ be the proportion of the molecules in unit of volume of the liquid whose velocity exceeds ε. Then, according to the author, since in equilibrium n is constant, the state of things is the same as if we had a gas containing n molecules per unit of volume permeating uniformly both the volume occupied by the liquid and that occupied by the vapour, and in addition a liquid with $N-n$ molecules per unit of volume. Hence if d be the density of the vapour, D that of the liquid, $\frac{n}{D} = \frac{n}{N}$. And at the critical temperature $d = D$, $n = N$.

If we make $z = \varepsilon\sqrt{h}$ where the absolute temperature is $\frac{3}{2h}$ we get—

$$\frac{d}{D} = \frac{2}{\sqrt{\pi}} z\, e^{-z^2} + \frac{2}{\sqrt{\pi}} \int_z^\infty e^{-t^2} dt$$

from which equation the author derives his results. S. H. B

61. *Liquid Mixtures* (Part II.). **R. A. Lehfeldt.** (Phil. Mag. 46. pp. 42–59, 1898.)—Measurements were made on mixtures of alcohol-benzene, alcohol-toluene, carbon tetrachloride-benzene, and carbon tetrachloride-toluene, giving the total vapour pressure in the neighbourhood of 50°—by the dynamic method—and the composition of the vapour—determined by means of the distillate. The apparatus used is described; the mixtures were analysed by their refractive index and tables of the refractive indices of the mixtures are given. From the experimental results, the partial pressures of the components are calculated, and show characteristic differences between the behaviour of alcohol and that of the normal organic liquids. Linebarger's rule for calculating the molecular complexity of liquids (Journ. Amer. Chem. Soc., vol. 17, No. 8) is discussed in the light of these numbers, and concluded to be incorrect. The results are compared with a thermodynamic relation between composition of liquid, composition of vapour, and vapour pressure (Lehfeldt, Phil. Mag. (5) 40. 398) and found in moderate agreement with it; and it is found that the relation

$$\log t = \log k + r \log q$$

holds over a wide range, for normal mixtures (those not containing alcohol), where t is the ratio of masses in the vapour,

q „ „ „ „ liquid,

k, r, are constants.

But this relation is purely empirical and does not hold for very dilute solutions of either liquid in the other. AUTHOR.

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62. *Irreversible Processes.* **O. Wiedeburg.** (Wied. Annalen. 64. 3. pp. 519–548, 1898.)—In continuation of his previous papers (see 1898 Abstracts, Nos. 32 and 739) the author states that the main point advocated by him as against the prevailing opinion is the constancy of the "heat contents" of a body, which cannot be transformed into other forms of energy. For the theorem of the constancy of the sum of the quantities $c\ d\ \theta + c'\ d'\ \theta$ we must substitute the law of the constancy of the total energy. The occurrences in the calorimeter especially should be represented by equations between energies, not quantities. The conception of "entropy" due to Clausius is identical with the old idea of "heat contents." The specific heat of a body is independent of its condition and its manner of changing it. As regards the specific heat of pure metallic solids, the author deduces several laws from his theoretical considerations which are confirmed by experiment. E. E. F.

SOUND.

63. *Vowel Sounds.* **Marage.** (Journ. de Physique, 7. pp. 449–455, 1898.)—When investigated by means of photographs of manometric flames, the (French) vowel sounds I, U, OU are seen to be characterised by the vibrations of a single flame, and A by those of three flames. E, EU, and O are formed by superimposing the A sound upon I, U, and OU respectively, and the appearance presented is that of the vibration of two flames. In singing, the spoken vowel sound is usually drowned by the sound proceeding from the vocal chords. In many instances the singer has the choice between mispronouncing the vowel and singing sharp or flat. The resonances of the nasal and buccal cavities must be suppressed in favour of the laryngeal note.

E. E. F.

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64. *Vowel Sounds.* **Monoyer.** (Comptes Rendus, 126. pp. 1637–1639, 1898.)—The 15 vowel sounds of the French language may be arranged in a scheme based upon the sounds of *ou*, *u*, and *i*, which have an interval of an octave each between them. The sounds of *oh* and *ah* occur within the first octave, and those of the obscure *e* and the open *e* in the second octave, being in each case represented by *re* and *fa* respectively. The nasal vowels *on*, *an*, *un*, and *in* are produced by the addition of a constant note which resounds in the nasal cavity. All the above remarks apply to whispered vowels, as whispering is the only means of eliminating the fundamental laryngeal note. E. E. F.

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65. *Photography of Manometric Flames.* **E. L. Nichols** and **E. Merritt.** (Phys. Rev. 7. pp. 93–101, 1898.)—The work described in this paper was undertaken in order to determine to what extent the manometric flame, with the aid of photographic methods, could be made useful in the study of the human voice. A specially suitable manometric flame was obtained by burning a jet of mixed acetylene and hydrogen in a stream of oxygen. A series of fine photographs are given, including records of several words. The highest speed attained by the celluloid film was 5 m. per second. It was found that in ordinary speech the pauses between words are not longer than those between syllables. Most of the high and delicate overtones of the sibilant consonants cannot be traced in the records obtained. E. E. F.

ELECTRICITY.

66. *Electrostriction and Electrodynamic Equation of a Moving Material Medium.* **J. Larmor.** (Roy. Soc. Proc. 63. pp. 365–372, 1898.)—In this note, intended as a supplement to his third memoir, the author justifies his assumptions of the former memoirs concerning the kinematical properties of ether. These being assumed, it remains to transform the molecular equations, which have to do with separate molecules, into differential equations which take cognisance only of the properties of an element of volume. When this transformation leads to infinities, the difficulty is to be evaded by the use of a principle which the author calls *the mutual compensation of molecular forcives*—that is, the infinite term represents a finite part of the result depending solely on the local molecular configuration, and the principle asserts that it may be omitted in estimating the mechanical effect on an element of volume. Without in the present paper giving the demonstrations, the author gives the general results at which he arrives, and shows that they satisfy Ampère's circuital relation, and also satisfy Faraday's circuital relation, provided the velocity attributed to moving matter is uniform in direction and magnitude. He discusses further the phenomena referred to in Arts. 79, 80 of the former memoirs. S. H. B.

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67. *Axial Field of a Bobbin in the form of a Truncated Cone.* **L. Houllevigue.** (Journ. de Physique, 7. pp. 466–468, 1898.) I is the current in C.G.S. units, n the number of turns per unit length measured along the slope of the cone, β the angle the slope makes with the axis, α_1 and α_2 the angles lines joining the larger and smaller bases and any point P in the axis make with the axis respectively.

Then the field at P or

$$f = 2\pi n \mathrm{I}\left[\sin^2\beta \log \frac{\tan\frac{\alpha_1+\beta}{2}}{\tan\frac{\alpha_2+\beta}{2}} - \cos(\alpha_1+\beta)+\cos(\alpha_2+\beta)\right]$$

At the summit of the cone the above expression becomes indeterminate but can be evaluated as

$$f_s = 2\pi n \mathrm{I} \sin^2\beta \log \frac{\mathrm{R}_1}{\mathrm{R}_2}$$

R_1 and R_2 being the radii of the larger and smaller bases respectively.

The author has employed this form of bobbin to regulate the

interior axial field of a cylindrical bobbin. A bobbin is taken of length equal to ten times its radius, the two ends are thinned down to form truncated cones over a length equal to three radii, the radius of the smaller base being 3/4 that of the cylinder. The axial field within two radii on either side of the centre does not vary one in 1,000, while in the case of an ordinary cylinder of the same dimensions the variation is 11 in 1000 for the same length. E. C. R.

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68. *Electromagnetic Theory.* **O. Heaviside.** (Electrician, 41. pp. 154–156, 323–325, 549–552, and 783–786, 1898.) A series of articles on this subject. EDITOR.

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69. *Electric Density on an Insulated Ellipsoidal Conductor.* **E. Armanini.** (N. Cimento, 7. pp. 377–382, 1898.) If a, b, c, be the semiaxes of the ellipsoid h the electric density at the point x, y, z, on its surface, c the total charge, it is known that

$$h = \frac{c}{4\pi a b c \sqrt{\frac{x^2}{a^4} + \frac{y^2}{b^4} + \frac{z^2}{c^4}}}$$

If k be a parameter defined by

$$\frac{x^2}{a^4} + \frac{y^2}{b^4} + \frac{z^2}{c^4} = k^2 \qquad (1)$$

$$h = \frac{ck}{4\pi a b c}$$

Hence the lines of constant density on the ellipsoid are the lines of constant k, that is the intersections of the given ellipsoid by the family of ellipsoids whose equations are (1). In order that the intersection may be real it is found that, a and c being the greatest and least semiaxes, $a \geq k \geq c$.

By a somewhat similar method can be found the lines of greatest variation of density. S. H. B.

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70. *Diurnal Variation of Atmospheric Electricity.* **Chauveau.** (Paris, Soc. Franc. Phys. Bull. 120. pp. 1–3, 1898.) The author, from the readings obtained at the Central Meteorological Bureau (Paris) and the Eiffel Tower, comes to the following conclusion: (1) At the Meteorological Bureau there are two maxima (7 to 8 p.m., and 7 to 10 a.m.) and two minima (one in the afternoon, the other during the night between 3.30 and 4.30 a.m.). (2) At the same place in summer the minimum in the afternoon is much more pronounced than that at night, although the latter

is clearly marked. In winter the minimum in the afternoon and the maximum in the morning are only feebly indicated. (3) At the Eiffel Tower in summer the atmospheric electricity has only one maximum and one minimum, and thus resembles the conditions found near the surface (at the Bureau) in the winter. The author finds that measurements made in towns or even near railways are quite unreliable. W. W.

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71. *Diurnal Variations of Terrestrial Magnetism.* **G. Lüdeling.** (Berlin Akad. Sitzber. 36. pp. 524–530, 1898.)—By combining the diurnal variations in the north-south X component of the horizontal magnetic force with the east-west Y component, Bezold has obtained his vector diagrams, which form closed, but very irregular curves, which he refers to the astronomic and not to the magnetic (Lloyd, Airy) meridian. Calculating these values for June and July, 1883, for the observatories at Cape Thorsden, Jan Mayen, Bossekop, Sodankylä, Godthaab (latitudes from 78 down to 67°) and further for Pawlowsk (lat. 59° 41′), Lüdeling finds that the movement of the radius vector in the polar regions is counter clockwise, if all days are considered, but clockwise—as generally in medium latitudes (Schuster) and also at Pawlowsk—if quiet days alone are taken. All the vectors cross the astronomic meridian before noon (between 10 and 11.30) and again more than 12 hours later. Other polar stations show similar relations; but the curve for Kingua Fjord (lat. 66° 36′, long. 67° 19′ W.) is always, winter and summer on quiet and disturbed days, a fairly regular oval with a clockwise motion. It would appear that the variations and the disturbances, though both ultimately to be traced back to the sun, may have different causes. H. B.

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72. *Magnetic Elements at Potsdam*, 1897. **M. Eschenhagen.** (Wied. Annalen, 65. 4. pp. 951–952, 1898.)—The following are the values for 1897 in absolute measure:—

	Values.	Difference from 1896.
Declination.....	10° 9·7′ W	— 4·6′
Horizontal Intensity ...	0·18775 c.g.s.	+ 0·00028
Vertical Intensity	0·43398 c.g.s.	— 0·00006
Dip	66° 36·3′ N	— 2·1′
Total Intensity	0·47286 c.g.s.	+ 0·00007

Magnetic storms were observed on Jan. 2, April 2, 20, 23, Dec. 11, 20, 21.

The magnetic survey during 1897 was carried out at 32 stations lying within a radius of 40 kilometres of Potsdam. The observatory is threatened by the extension of the electric tramways.

E. E. F.

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73. *Lightning Discharges from Transmission Lines.* **C. P. Steinmetz.** (Elect. World, 32. pp. 203–205, 1898.)—A mathematical paper dealing with the problem of the oscillating discharge of a transmission line when charged by induction from a thundercloud. The conclusion arrived at by the author is that the fundamental frequency of the discharge is relatively low, and of not much higher magnitude than frequencies in commercial use.

A. H.

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74. *Dielectric Properties of Ice.* **R. Abegg.** (Wied. Annalen, 65. 4. pp. 923–925, 1898.)—In a previous paper (see 1898, Abstract No. 1058) the author stated that Nernst's dielectric apparatus was unsuitable for the measurement of dielectric constants of bodies such as ice. Subsequent experiments have proved this to be erroneous.

E. E. F.

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75. *Multiplication of the Secondary Discharge of a Condenser.* **R. Swyngedauw.** (Comptes Rendus, 126. pp. 1788–1789, 1898.)—The circuit joining the armatures of a jar contains a primary exciter and coil, and subsequently bifurcates into two branches, one interrupted by the interpolar space of a secondary exciter, the other consisting of a secondary coil; the branches come together again, and their junction is connected by a short conductor to the second armature. It has been shown experimentally that, if the secondary spark-gap exceeds a certain limit, the quantity of electricity which passes through the secondary coil is far greater than the charge of the condenser. The author states that he has succeeded in accounting for this by applying the general laws of induction. The actual analysis is not given. It appears that the augmentation of the secondary discharge cannot occur unless that in the principal circuit is alternating.

G. B. M.

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76. *Discharge of Condensers.* **A. Garbasso.** (Torino, R. Accad. Sci. Atti, 33. pp. 436–444, 1897–98.)—A large Leyden is discharged through a circuit, part of which consists of two parallel branches, one of much greater resistance than the other. By means of a commutator, a spark-gap may be inserted in one or the other branch. The sparks are observed by a rotating mirror arrangement. The discharge through the thick branch is always clearly alternating; that through the thin one seems to be occasionally aperiodic, but more frequently oscillating and rapidly damped. The author describes an apparatus which shows what is (roughly) a hydrodynamical analogue.

G. B. M.

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77. *Dielectric Strength of Air.* **C. P. Steinmetz.** (Amer. Instit. Elect. Engin. 15. pp. 327–372, 1898.)—This is a continuation of the author's researches on high voltage discharges. The apparatus used is a series of step-up transformers as described in Abstract No. 509, 1898. The following results are arrived at :—

1. At constant voltage and constant wave shape, that is constant ratio between maximum and effective E.M.F., the striking distance (in air) is a constant, especially between sharp points, where the tests have been repeated over and over again, and independent of the atmospheric condition, the frequency, &c., to such an extent that the striking distance between needle-points offers the most reliable means to determine very high voltages. For this reason it is used as a final check in all high potential insulation tests of the General Electric Company.

2. No physical law has been found to represent satisfactorily all the observations. Some point to the existence of a constant dielectric strength of air, analogous to the tensile strength of mechanics. Others point to the existence of a spurious counter E.M.F. of the spark or transition resistance from electrode to air.

3. Constant dielectric strength. Cylinders of 1·11″ diameter give an average disruptive strength of air of 60 kilovolts per inch ; cylinders of 0·315″ diameter, an average dielectric strength of 77. Spheres at a very small distance point toward the latter value. As a disturbing factor in this case, enters the electrostatic brush discharge, which, by a partial breakdown of the air surrounding the electrodes, changes and increases the size and decreases the distance of the effective terminals.

4. Counter E.M.F. of the sparks. The tests with sharp points give 22 kilovolts, or 11 kilovolts for a single transition from terminal to air. Spheres give curves pointing to a similar phenomenon. Electric conductors inserted at right angles into or parallel with the discharge point to the existence of a counter E.M.F. of the same magnitude. The beginning of the electrostatic brush discharge is at a potential of this magnitude also.

5. Potentials of 160,000 volts effective and even up to 170,000 volts have been experimented with. They are probably the highest voltages ever reached at ordinary frequencies with alternating currents of considerable power—about 30 kilowatts.

W. G. R.

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78. *Electric Discharge in a Liquid Dielectric.* **L. Décombe.** (Comptes Rendus, 126. pp. 1197–1198, 1898.)—When the electric discharge takes place across a liquid dielectric, its character appears different from that seen in the case of air. When a spark through oil of vaseline was studied by means of a rotating mirror there was found to be no alternation from one extremity of the image to the other, as if at the same instant the spark possessed the same brightness over all its length. The volatilisa-

tion of the metal at the negative electrode seems hindered by the presence of the liquid, a tearing away of solid incandescent particles as at the positive electrode takes place, the spark then would be entirely made up of solid incandescent particles, of which the brightness would follow a periodic law synchronous with that of the discharge. J. J. S.

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79. *Discharge of a Leyden Jar.* **R. Swyngedauw.** (Comptes Rendus, 126. pp. 1628–1630, 1898.)—A Leyden jar is discharged round a circuit of two coils in series. The author concludes from his experiments that the discharge current is uniform, and that the maximum potential, V, attained between the extremities of the double coil is the sum of the maximum potentials, v_1 and v_2, attained at the extremities of each of the coils.

$$V = v_1 + v_2$$

and—

$$V = (L_1 + L_2)\frac{d\,C}{d\,t}$$

J J. S.

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80. *Variation of Gaseous Pressure in Vacuum Tubes.* **G. Séguy.** (Comptes Rendus, 127. pp. 385–387, 1898.)—The pressure in a vacuum tube traversed by an electric discharge is neither uniform nor constant. This may be proved by means of a glass tube 4 m. long, bent double in lengths of 25 cm., and provided with electrodes at the two ends. It is exhausted to a millionth of an atmosphere and connected with an induction coil or a transformer. It is found that while at the kathode end the original exhaustion is maintained, the exhaustion at the anode falls to one-thousandth of an atmosphere, as shown by the usual forms of discharge. The portion of the tube near the anode is soon filled with gaseous molecules. On reversing the current, these molecules are pushed into the other half of the tube. The author supposes that the metallic particles projected from the kathode aid in maintaining the vacuum there by sweeping the gaseous molecules into the walls of the tube.

E. E. F.

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81. *Vacuum Tubes.* **L. Bonetti.** (Comptes Rendus, 126. pp. 1893–1894, 1898.)—The author varies the degree of vacuum within a vacuum tube, regenerating a tube which has become too hard by subjecting a platinum wire within it to incandescence by means of an electric current. A. D.

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82. *Circulation of Gaseous Matter in Crookes Tubes.* **A. A. C. Swinton.** (Phil. Mag. pp. 387–395, 1898.)—Radiometer mill wheels are employed to detect the return stream of the particles that form the kathode rays. Such wheels, when arranged in high vacuo, so as to be just outside the kathode stream, are found to rotate in a direction that indicates a return stream from the anode to the kathode outside of the opposite kathode stream. Mills both of paddle-wheel and screw-propeller form give this result, and gilding the mica vanes does not materially affect matters. The action cannot therefore be due to electrification, nor does it appear to be caused by thermal radiation. The author suggests that while at low exhaustions the discharge may be conveyed through the tube by an interchange of electrical charges from molecule to molecule on the Grotthus chain principle; at high exhaustions there may to some extent be a complete circulation of the positively and negatively charged atoms, some of which may make the entire journey from anode to kathode or *vice versâ*, and deliver up their charges not by interchange with other gaseous atoms, but by direct convection to the electrodes of apposite sign. AUTHOR.

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83. *Kathode Fall of Potential in Gases.* **J. W. Capstick.** (Roy. Soc. Proc. 63. pp. 356–365, 1898.)—A current from a battery of storage cells was sent through the gas, which was at a pressure of 1 or 2 millimetres. When the current is constant the fall of potential between the kathode and a point just outside the negative glow is independent of the current strength and of the pressure of the gas. This fall of potential was measured for several gases, with the following results:—

Hydrogen	298 volts
Nitrogen	232 ,,
Oxygen	369 ,,
Water vapour	469 ,,
Ammonia	582 ,,
Nitric Oxide	373 ,,

The accuracy of the last is doubtful, for the gas is very rapidly decomposed by the current, and a trace of oxygen has a large effect on the kathode fall. Leaving nitric oxide out of account, the values found are approximately additive. In the elementary gases the current is generally continuous, but in the compound gases it is almost always intermittent, which makes readings difficult to obtain for these. AUTHOR.

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84. *Chemical Action of Kathode Rays.* **J. J. Thomson** and **S. Skinner.** (Cambridge Phil. Soc. Proc. 9. 7. pp. 371 372,

1898.)—Aluminium is rapidly evaporated from a kathode by the electric discharge in a highly exhausted vacuum tube containing mercury vapour. The metal forms a bright mirror on the walls of the tube. An iron kathode gives a similar mirror in mercury vapour. When the aluminium coating is dissolved off by hydrochloric acid, a gelatinous membrane of silica is left. The iron mirror dissolves away completely. Possibly the aluminium driven off from the kathode acts on the glass, forming a silicide. When potassium vapour is used in the place of mercury vapour, the glass opposite the kathode is roughened, although the aluminium is not extensively evaporated. Parts protected by screens are not attacked. In this case the action on the glass may be attributed to the potassium driven against it by the kathode discharge. Opposite the kathode, both in mercury and potassium vapours, a dark annular stain of the shape of the kathode is formed. The stain appears to be carbon, but the quantity was too small for definite tests. It is formed on mica, quartz, and calcite screens. Monatomic gases appear to especially facilitate the evaporation of carbon, as Professor Callendar has observed its evaporation in argon vacuum tubes. S. S.

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85. *Kathode Rays.* **P. Villard.** (Comptes Rendus, 126. pp. 1564–1566, 1898.)—From the results of his experiments, in which a reducing action is exerted by the kathode rays, the author is led to the conclusion that they consist of particles of hydrogen, which he thinks is furnished by the imperfectly dried glass, there being no means of completely getting rid of the water by drying agents. J. J. S.

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86. *Kathode Rays.* **P. Villard.** (Comptes Rendus, 127. pp. 173–175, 1898.)—Two bundles of kathode rays have no appreciable action upon one another when they cross, unless one of the bundles encounters lines of force. The behaviour of kathode rays under variations of form and position is discussed. A. D.

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87. *Reflection of Kathode Rays.* **H. Starke.** (Wied. Annalen, 66. 1. pp. 49–60, 1898.)—Kathode rays are projected from a side tube into a spherical vessel, in the centre of which a flat metallic mirror is mounted, which can be moved about a vertical axis from outside. After reflection, the rays are caught in another side tube at an angle of 60° to the first. This side tube contains an electrode constructed on the model of Faraday's ice-pail. The results show that the reflection is diffused, since the galvanometer shows the same deflection whatever the orientation of the mirror, provided the same face is turned towards the two electrodes. The reflection is considerably

reduced by connecting the mirror to earth and thus discharging the kathode particles. The reflective powers of various metals are in the same order as their densities, but not in the same proportion. E. E. F.

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88. *Period of Electrical Oscillations.* **A. G. Webster.** (Phys. Rev. 6. pp. 297–314, 1898.)—The electrical oscillations considered are set up by the discharge of an air-condenser through a coil of copper wire wound inductively, the capacity of the condenser and the inductance of the coil being calculable from their dimensions. The condenser and both pairs of quadrants of a Mascart-Kelvin electrometer are charged to the same high potential; an electrical contact is broken, causing one pair of quadrants to discharge suddenly, and the condenser and the other pair of quadrants to discharge in parallel in an oscillatory manner through the inductive resistance. At a measured interval after the commencement of discharge the electrometer quadrants are insulated, thus showing the condenser potential at the end of the interval. The interval is obtained by the free fall of a projectile liberated by an electromagnetic device, and the author describes the precautions necessary for securing an accurately straight fall; the contacts are broken successively by the impact of the projectile against levers. The results give for "v" the value $3{\cdot}0259 \times 10^{10}$ cm. per sec. and confirm the formula for the period of condenser oscillations. J. L. H.

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89. *Electric Oscillations.* **Drude.** (Zeitschr. Elektrochem. 4. pp. 492–494, 1898.)—For each given wave-length each substance has a particular dielectric constant and a particular coefficient of absorption. The latter can in many cases be calculated from the conductivity, the period of oscillation and the dielectric constant; in others not. In these latter cases of abnormal absorption, the absorption is much greater than corresponds to the conductivity: thus amyl alcohol absorbs waves 75 cm. long in much the same proportion as a saline solution of 20,000 times its conductivity. Abnormal absorptions seem to be associated with the presence of hydroxyl-groups: and in such cases the dielectric constant rapidly falls off as the period of oscillation diminishes. A. D.

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90. *Hertzian Oscillations and Metal.* **E. Branly.** (Comptes Rendus, 127. pp. 43–46, 1898.)—Electrostatic induction does not act within a metal cage: current induction does: but Hertzian oscillations are completely excluded even by a very thin-walled metal cage if it be hermetically closed, or if the metal be a very fine gauze: not if there are any linear apertures in it. The amount of action within varies with the size and direction of the slit. A. D.

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91. *Hertzian Field in Air and in Oil.* **A. Turpain.** (Comptes Rendus, 126. pp. 1630–1632, 1898.)—A Hertzian resonator kept in the same plane as the wires which concentrate the field (position II.) discloses a system of nodal and ventral segments alternating with those which it indicates in the classical position, perpendicular to the direction of the wires (position I.), the nodes of one of the systems coinciding with the loops of the other and inversely.

From his experiments conducted in air and in oil the author concludes that—

1. The wave-lengths revealed by a resonator kept in position I. vary with the nature of the dielectric in the midst of which the phenomena occur. They are less in oil than in air.

2. For position II. the wave-lengths are independent of the nature of the dielectric in which they are measured. They are equal in air and in oil. J. J. S.

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92. *Electric Resonators.* **Oudin.** (Comptes Rendus, 126. pp. 1632–1634, 1898.)—A description of the effects got with the author's high frequency apparatus. He now uses a solenoid of fine copper wire, not insulated, coiled on a cylinder of paraffined wood. The high frequency may be obtained by an influence machine or by the arrangements of Hertz or Tesla, but best by d'Arsonval's method in which a spark passes between the inner coatings of two Leyden jars. From the last spire of the resonator bright luminous tufts or plumes dart out. The resonator creates in the region around it a very intense alternating electrostatic field, and sparks may be drawn from surrounding metallic objects. Sparks may also be got from the body of a person whose hand is placed near the discharge. The physiological effects are referred to and the action on a Crookes tube. The prolonged action of the high frequency discharge on the skin produces results analogous to those of Röntgen rays. J. J. S.

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93. *Electromagnetic Waves.* **C. Gutton.** (Comptes Rendus, 127. pp. 97–100, 1898.)—If Hertzian waves are transmitted along two parallel wires whose extremities are joined by a bridge the electric force is constantly zero at the middle of this bridge. The author has sought to find how the passage of the waves takes place over a secondary wire arranged parallel to the primary wire in the region near the point of zero electric force. Waves transmitted from the same exciter along parallel wires arrive at the same resonator at the ends of the wires in concordance; if one of the wires is interrupted and the wave transmitted to a secondary wire by means of a bridge of two concentric circular wires a difference of phase of a half-period is introduced. As to the effect on the form of the train of waves of passing from one wire to another, it is found that the exciter sending out damped

pendular vibrations, the secondary waves are of the same form, and have the same period and the same damping, only the amplitude of the vibration is diminished by the passage of the waves to the secondary conductor. The author explains these results by a consideration of the behaviour of the lines of force.

J. J. S.

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94. *Dielectric Hysteresis.* **H. Benndorf.** (Wied. Annalen, 65. 4. pp. 890–893, 1898.)—A paper similar to that referred to in Abstract No. 1241, 1898. E. E. F.

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95. *Internal Resistance of Standard Cells.* **I. Klemenčič.** (Wied. Annalen, 65. 4. pp. 917–922, 1898.)—The author points out the importance of the internal resistance of standard cells in certain standardising operations. Some of the standards manufactured according to the Reichsanstalt precepts show enormous variations of resistance with temperature. One of them, made by Fuess, had 8,620 ohms at 20·8° and 30,800 at 11°. The straight form of the Clark cell, though inferior as regards E.M.F., has distinct advantages over the H-form in the matter of resistance.

E. E. F.

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96. *Resistance of the Human Body.* **J. E. Boyd.** (Phys. Rev. 7. pp. 115–118, 1898.)—A reading was taken with a Duncan dynamometer in series with a non-inductive resistance of 1,550 ohms which was then replaced by the body. The fingers were dipped into a solution of ammonium chloride, two large battery carbons forming the electrodes. For alternating currents of from 2 to 7 volts, 0·0014 to 0·0044 ampere and 62 periods, the resistance, hand to hand, varied between 1,478 and 1,622 ohms; for continuous currents of about the same strength and tension betweeen 1,598 and 2,078 ohms. In a second series of tests, Ayrton's method was applied, the current being measured by a Weston voltmeter, and the drop of potential with a condenser and galvanometer. Platinum foil strips, fastened to the body, served as condenser terminals. By this method the total resistance, jar to wrist, wrist to wrist, wrist to jar, aggregated 1,334 ohms. The hands above the liquid were not thoroughly dry; hence probably the smaller resistance. H. B.

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97. *Resistance of the Human Body.* **Dubois.** (Comptes Rendus, 126. pp. 1790–1792, 1898.)—In these experiments a condenser is connected with a battery for a very short period by means of a steel ball impinging on a mass of steel and rebounding. Various resistances are inserted in the path of the current,

and the results compared by means of a ballistic galvanometer. The author concludes *inter alia* that during the state of variable flow the resistance of the human body is much less than its ohmic resistance; that this resistance is unaltered, for the same position of the electrodes, in spite of large variations of the ohmic resistance; and that the body, considered as a condenser, has a capacity of about 0·165 microfarad. G. B. M.

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98. *Resistance of Incandescent Lamps.* **J. C. Schedd.** (Amer. Electn. 10. pp. 362–363, 1898.)—The author gives three definitions of electrical resistance, and applies them to the design of incandescent lamps. The variable temperature-resistance coefficient of carbon filaments, and the effect of abnormal temperatures on their resistance, are also discussed. A. H. A.

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99. *Measurement of Resistance of Incandescent Lamps.* **R. Apt** and **H. W. Hoffmann.** (Écl. Électr. 14. pp. 566–569, 1898; and Elektrotechn. Zeitschr. p. 122, 1898.)—The method usually employed for the above purpose is not strictly correct, the resistance being deduced from ammeter and voltmeter readings; the current taken by the latter, of course, introduces an error. The method suggested by the authors is a modification of that employed by E. Wiedemann, in which a Wheatstone bridge is used—the lamp being inserted in one of the branches. This method, although more accurate that the preceding one, does not make use of all the advantages of the Wheatstone bridge test. The authors propose to employ the bridge by causing an auxiliary current to pass through the lamp in addition to the main current. The connections are analogous to those of the Paalzoid and Rubens bolometer method. The above method possesses the disadvantage of being somewhat complicated, and also that if one of the lamp circuits is accidentally broken a strong current will pass through the battery and galvanometer and may injure them. L. J. S.

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100. *Conductivity of Hot Gases from Flames.* **J. A. McClelland.** (Phil. Mag. 46. pp. 29–42, 1898.)—In this paper the nature of the conductivity which is observed in gases coming from flames is investigated. The flame used is that of an ordinary Bunsen burner, and the gas is drawn along a brass tube in which is placed an insulated terminal which can be raised to any required potential, and the conductivity is given by the rate of leakage of this terminal as shown by an electrometer.

The relation between current and E.M.F. is investigated, and the result shows that the conductivity is due to the ionisation of

the gas in the flame. We have, then, a number of positively and negatively charged carriers which give to the gas its conductivity. The velocity of these carriers under an E.M.F. is measured by a method described in the paper, and found to be ·2 cm. per second for a potential gradient of 1 volt per cm. This velocity is much less than has been found for the carriers in gas which has been exposed to Röntgen rays, and points to the carrier having joined on to itself a number of uncharged particles, which increase its mass without increasing the charge, and thus diminishing the velocity.

A difference between the velocity of the positive and negative carriers was also detected, the velocity of the negative being about 15 per cent. greater than that of the positive. As the charges of the positive and negative carriers are probably the same, the positive must have more uncharged particles attached to it. The velocity of the carriers was found to diminish rapidly as the gas cooled at some distance from the flame, which would point to a further condensation on the carrier of some uncharged body.

At a distance from the flame the gas loses a much smaller percentage of its conductivity by passing through fine gauze than if the gauze is placed nearer the flame. This is explained by the diminished velocity of the carrier under an E.M.F. at a distance from the flame, so that fewer carriers come into contact with the gauze by diffusion. The rate of recombination of the positive and negative carriers is also investigated, and is approximately proportional to the square of the number present. AUTHOR.

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101. *Electric Conductivity of Flame Gases.* **K. Wesendonck.** (Wied. Annalen, 66. 1. pp. 121–135, 1898.)—The flame gases examined were the products of combustion of a Bunsen burner, aspirated through a cooling chamber and a wash-bottle into a jar containing a charged disc connected with an electrometer. Any remaining conductivity was thus indicated by a discharge of the electrometer. It was found that while cotton- or glass-wool completely abolished the conductivity of flame gases, bubbling through water had no effect whatever upon it. Bubbling through mercury, sulphuric acid, permanganate of potash, turpentine, and glycerine, were equally inefficient. Hot sulphuric acid was the only means of completely discharging the gas. The result was the same with a negative as with a positive charge. The number of dissociated ions is probably infinitesimal in comparison with the number of undissociated ions in the gas.

E. E. F.

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102. *Measurement of Single Potential Differences.* **H. R. Carveth.** (Journ. Phys. Chem. 2. pp. 289–321, 1898.)—The first part of this paper contains a review of the methods which

have been used to determine single differences of potential, *i.e.*, that of Lippmann by using the capillary electrometer, and that of dropping mercury into an electrolyte. In the second part a series of experiments are made by the dropping mercury method. The potential difference between a given metal and an electrolyte, into which the mercury drops, is measured by connecting the metal and mercury to a potentiometer. The measured potential difference is found to vary with the concentration of the electrolyte. The values are not in agreement with those of Paschen obtained by the same method, nor with those obtained by the Lippmann method.

The principal conclusion to be drawn is that neither on the ground of the Helmholtz theory, the Warburg theory, nor that of Nernst is there reason for regarding one single potential difference as known. Cases where the dropping electrode gives values corresponding to the polarisation method have been observed, as well as cases in which a difference occurs. It is found that the values obtained for different concentrations follow in regular order, and that both the anion and kation affect the values. Nernst's solution pressure formula holds approximately in a few cases, but in the great majority fails. The main query of the paper, "Are the values given by the drop electrodes true single differences of potential?" must be answered in the negative.

S. S.

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103. *Electric Arc.* **J. Sahulka.** (Zeitschr. Elektrotechn. Wien, 16. pp. 213–216, 1898.)—When one end of a galvanometer circuit is joined to one of the electrodes of an alternating arc, and the other to a small auxiliary carbon which is inserted in the arc, indications of a direct electromotive force are obtained. The author discusses the theory of this, and gives the results of some of his own experiments. G. B. M.

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104. *Thermo-Electromotive-Forces in Crystallised Bismuth.* **L. Perrot.** (Comptes Rendus, 126. pp. 1194–1197, 1898.)—A comparison has been made between the thermo-electric forces in crystallised bismuth when the current traverses the bismuth perpendicularly to the principal cleavage and when it traverses it parallel to this cleavage. Junctions of copper and bismuth were used, and the electromotive forces were measured by two methods: (1) by the deflections directly produced on a sensitive galvanometer, (2) by the potentiometer method.

The following are the general results:—

1. The E.M.F. for 1° difference between the temperatures t and t' of the junctions goes on increasing with the temperature between 10° and 100°.

2. This increase is more rapid for the junctions where the surfaces of contact are perpendicular to the cleavage than for the

junctions where the surfaces are parallel to the cleavage : hence the ratio of the E.M.F.'s (parallel : perpendicular) goes on diminishing in proportion as $(t + t')$ increases. In one of the experiments t being kept at 11°, the ratio when t' was 20° was 2·33 ; when t' was 100° the ratio was 2·00.

3. As to the absolute values of the electromotive forces : the temperature of the cold junction t being 11°, the E.M.F. in volts was :—

For t'	30°	50°	70°	95°
Parallel to cleavage	0·00190	0·00396	0·00610	0·00899
Perpendicular to cleavage	0·00084	0·00185	0·00299	0·00447

The results indicate that the crystalline structure has on the thermo-electric constants of bismuth a greater influence than has hitherto been supposed. J. J. S.

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105. *Theory of Coherers.* **D. van Gulik.** (Wied. Annalen, 66. 1. pp. 136–145, 1898.)—Some experiments are described which should decide between the coherer theories put forward by Lodge and Branly respectively. The action of electric waves upon a gap between the spherical ends of two thin platinum wires, as observed under the microscope, drew the ends together when their distance apart was reduced to 0·004 mm. They remained sticking together after the radiation had ceased. In another experiment two mercury drops, separated by a thin surface contamination of chalk, coalesced under the influence of electric radiation. These experiments prove that actual metallic contact is created, and controvert Branly's hypothesis of a modification of the intervening dielectric. E. E. F.

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106. *Materials for Coherers.* **E. Dorn.** (Wied. Annalen, 66. 1. pp. 146–161, 1898.)—The noble metals—platinum, gold, and silver—give practically no coherer action. Iron gives good results, especially after a short exposure to air. Copper, immediately after filing, shows no change of resistance. After five hours a slight coherer action is observed, and in three weeks the resistance may rise to 300,000 ohms, which falls to 10 ohms under the influence of electric radiation, and rises to 187,000 ohms on concussion. Neither exhaustion nor heating have any influence upon a tube containing aluminium filings. In tubes containing nickel, iron, copper, or zinc, heating leads to a diminution of the resistance, which in zinc is probably due to sublimation. E. E. F.

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107. *Polarisation.* **Heim.** (Zeitschr. Elektrochem. 4. pp. 527–534, 1898.)—The potential difference, p_1 between the poles of an electrolytic cell with insoluble electrodes for the passage of

a constant current i is equal to e, the polarisation for that current density added to the electromotive force needed to maintain the current through the resistance r of the cell :—

$$p_1 = e + ir$$

Again, if the cell is divided completely by a thin wall of the same material as the insoluble electrodes, the resistance r of the cell is practically unaltered, but the value of e is doubled since the current enters one face of the thin septum and passes out from the other. If the current is maintained equal to i, we have for the new potential difference p_2 :—

$$p_2 = 2e + ir.$$

From the two readings of potential difference it follows :—

$$e = p_2 - p_1.$$

The author gives details for carrying out this method, and some examples. S. S.

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108. *Differential Telephone for Measurement of Electrolytic Conductivity.* **R. Federico.** (N. Cim. 4. 6. pp. 161–171, 1897.)—The author describes a differential telephone and its application for measuring electrolytic resistances in the same way as a differential galvanometer is used in the case of metallic wires. S. S.

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109. *Standards of Measurement.* **H. S. Carhart.** (Science, 8. pp. 326–327, 1898.)—In the determination of the mechanical equivalent of heat by electrical methods, Griffith's results exceed those of Rowland by about 1 part in 400 at all temperatures between 15° and 25° on the nitrogen scale. Those of Schuster and Gannon exceed Rowland's at 19·1° on the same scale by about 1 part in 500. Since the electrical methods employed involve either the current and the E.M.F. of the Clark cell or the square of this E.M.F., and since the E.M.F. of the Clark cell is determined by the silver voltameter, it follows that the current enters into the result as a square. If the discrepancy is due entirely to an error in the value of the ampere, assuming the ohm to be correct, then the ampere should be 1 part in 1,000 to 1 part in 800 larger than the at present accepted value ; that is, the electro-chemical equivalent of silver should be increased from Lord Rayleigh's value of 0·001118 to 0·0011191 or 0·0011194.

The method used by Patterson and Guthe at the Ann Arbor physical laboratory, Michigan, was that of a specially constructed electro-dynamometer of large dimensions, and the employment of the torque of a phosphor-bronze wire to equilibrate the counter-torque due to the effort between the stationary and movable coils.

The torque of the wire was measured by observing the period of vibration of a cylindrical brass weight of known mass and dimensions when suspended by the wire. The entire success of this part of the investigation was due to the fact that the whole apparatus was enclosed in a fairly good vacuum. Under these conditions the vibrations could be followed for hours at various intervals; the logarithmic decrement was almost entirely constant, and it was easy to obtain a curve connecting temperatures and periods of vibration. The wire was so connected to the support and to the brass cylinder that it could be transferred from the vacuum apparatus to the electro-dynamometer and back again without disconnecting it from the terminal pins.

The weights employed were compared with the standards at the U.S. Bureau of Weights and Measures in Washington; the standard of length was a half-meter bar of speculum metal made for the University of Michigan by the late W. A. Rogers. The time was taken by a standard Riefler clock, checked by the observatory time. The result of the investigation is that the electro-chemical equivalent of a used solution of neutral silver nitrate, 15 parts by weight of silver salt to 85 parts of distilled water is 0·00111192. This exceeds Rayleigh's value by about $\frac{1}{6}$ of 1 per cent., and causes the discrepancy in the mechanical equivalent of heat to disappear.

The corresponding change in the E.M.F. of the Clark cell will be from 1·4342 to 1·4327 at 15° C. E. C. R.

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110. *Manganin Standard Resistances.* **W. Jaeger** and **St. Lindeck.** (Wied. Annalen, 65. 3. pp. 572–589, 1898.)—A paper similar to that referred to in Abstract No. 647, 1898.
E. E. F.

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111. *Capillary Electrometer.* **C. F. Burgess.** (Amer. Instit. Elect. Engin. 15. pp. 379–388, 1898.)—Describes a form of capillary electrometer that the author has found very convenient for testing, and which is both light and portable.

The electrometer consists of a rather thick glass tube having a platinum wire sealed in the lower end, which is closed. A layer of mercury covers the wire, and the tube is nearly filled with the electrolyte, consisting preferably of dilute sulphuric acid. A capillary tube, made by drawing out a piece of thermometer tubing, rests against the side of the glass, and is firmly held in place by a tightly fitting rubber stopper inserted in the top of the large glass tube enclosing an air space above the electrolyte. A piece of flexible rubber tubing is fitted on the upper end of the capillary, and filled with pure mercury, its upper end being closed by a piece of glass into which a platinum wire is sealed. A pinch-cock is put on the rubber tube, so that on compressing it mercury

is forced through the capillary, and on slightly releasing the pressure the mercury is drawn back, followed by the electrolyte. The instrument is then ready for use. The glass tube is held firmly upright by a brass collar attached to an ebonite support. A reading microscope having a micrometer eyepiece is held on an adjustable support, and is used for reading the movement of the meniscus. The apparatus is also fitted with a top and bottom contact key, which when up short-circuits the electrometer. If a pressure of over a volt is applied to the terminals electrolytic action takes place, destroying the sensibility. This is readily restored by compressing the rubber tube until a drop of mercury flows through, when on releasing the pressure the instrument is again ready for use. The direction of movement of the meniscus depends on the polarity, and the extent is approximately proportional through a limited range to the potential difference. This is not absolutely so, as it is impossible to get a capillary of perfectly uniform bore; for this reason the instrument should be used as a zero instrument. E. C. R.

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112. *Silver Voltameter and Standard Cells.* **K. Kahle.** (Zeitschr. Instrumentenk. 18. pp. 229–240 and 267–276, 1898.)—This is an investigation as to how far the silver voltameter can be relied upon for standardising. In the course of 115 measurements of the amount of silver deposited by the same current during 40 minutes' electrolysis, this amount varied between 0·97134 grammes and 0·97473 grammes. Under perfectly equal conditions as to current density, temperature, and treatment, an accuracy of 1 in 10,000 can be attained. A platinum surface receives somewhat less of a deposit than an already existing silver deposit. Fresh solutions deposit less readily than those which have already been electrolysed. To get rid of all $Ag\,NO_3$ in the deposit, repeated cold washing and subsequent washing for one hour in water at 80° is necessary. The result of the standardising experiments may be summarised as follows:—

Clark cell at 15°: Cadmium cell at 20° = 1·40663.
Also E.M.F. of Clark cell at 15° = 1·4328 int. volt.
E.M.F. of Cadmium cell at 20° = 1·0186 int. volt.
E.M.F. of Clark cell at 0° = 1·4492 int. volt.

E. E. F.

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113. *Ballistic Galvanometry.* **C. Barus.** (Phys. Rev. 7. pp. 10–18, 1898.)—Contains the mathematical theory of a suggested new form of instrument, in which the needle is held against fixed stops by means of a torsion-balance arrangement. G. B. M.

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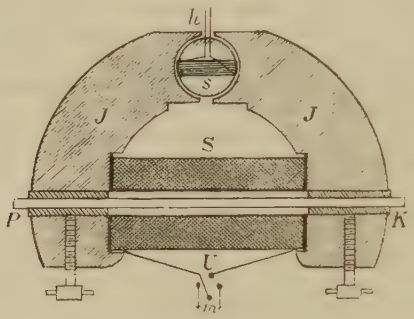
114. *Commercial Permeameter.* **M. Aliamet and E. J. Brunswick.** (Électricien, 16. pp. 187–191, 1898.)—This is a

description of a permeameter constructed by Hubert Kath. A section of the instrument is shown in the accompanying figure. The principle upon which it is based consists in reversing the function of a d'Arsonval galvanometer. Instead of measuring the strength of a current flowing in the movable coil of the apparatus by the deflection of the coil situated in a constant field, a constant current flows round, and the deflections measure variations in the field strength.

The instrument consists of a magnetic circuit composed of the bar *P* of the metal to be studied, and by two iron pole-pieces



J J of large section and consequently small reluctance. In the polar gap moves the coil. An iron core is placed within the coil to minimise the reluctance of the magnetic circuit. The bar *P* is carefully turned and is held in place by two screws. In series with the magnetising coil *S* are placed two compensating coils on *J J* wound in the opposite sense to eliminate the effect of the pole pieces, so that the flux passing through the coil is due solely to the bar *P*. W. G. R.

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115. *Electrostatic Wattmeter for High-Tension Alternating Currents.* **R. Arnò.** (Torino, R. Accad. Sci. Atti, 33. pp. 593–597, 1897–98.)—The author, having found by experiments on a paraffined paper cylinder in a rotating electrostatic field that for high inductions the work done in hysteresis is proportional to the square of the induction or of the voltage, applies this principle to the measurement of watts in a high-tension circuit. The wattmeter consists of four quadrants surrounding a metallic cylinder, with the paraffined paper cylinder in the annular space between. One pair of quadrants is connected to the two points giving the voltage of the circuit, and the other to the secondary of a transformer on open circuit, through whose primary passes the main current. The author then shows that the deflections of the wattmeter are proportional to the watts in the circuit. G. H. Ba.

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116. *Correcting Factor of Wattmeter.* **F. Loppé.** (Écl. Électr. 16. pp. 525–530, 1898.)—Taking the general case of a circuit in which the E.M.F. does not follow the sine law, the author deduces an expression (of very considerable complexity) for the correcting factor of a wattmeter in terms of the time-constant of the fine-wire circuit, the ratios of the amplitudes of the various simple harmonic terms which make up the E.M.F. wave, and the resistance and inductance of the main circuit. He then proceeds to show how the expression may (by an exceedingly laborious method) be applied to any given case in practice. A. H.

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117. *Electrostatic Voltmeter.* **Svilokossitch.** (Électricien, 15. pp. 199–201, 1898.)—The paper describes an electrostatic voltmeter constructed by Ebert & Hoffmann on the system adopted by Bjerknes (Wied. Annalen, 48. p. 594, 1893). A rectangular, thin aluminium plate is suspended by a quartz thread between two parallel and vertical metal plates. Its position of rest is at an angle of 45° with the plates, and a difference of potential between the plates produces a force tending to turn it parallel to the lines of force, the deviation, if small, being proportional to the square of the force if the field be assumed uniform. An aluminium wire fixed to the suspended plate carries the mirror, and, at its lower end, a magnet which gives a controlling force and at the same time damps the oscillations by being enclosed in a copper box. The fixed and suspended plates are completely enclosed in a metal case, the former being held by two horizontal rods passing through ebonite bushes in the case and provided with terminals outside. By varying the distance between these plates any desired sensibility may be obtained. A small model gave a deflection of 10 mm. at a scale distance of 1 metre with 64 volts, and without the directing magnet, 150 mm. The small capacity of the instrument renders it suitable for work with electrical oscillations. G. H. Ba.

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118. *Thermal Mercury Ammeter.* **C. Camichel.** (Comptes Rendus, 126. pp. 1028–1030, 1898.)—The thermometric ammeter previously described (see 1898, Abstract No. 412, and Phys. Soc. Abstracts, Nos. 604 and 705, 1897) may be used for the determination of current intensities to within 0·5 per cent. in one minute. Its indications are very constant. It may also be used as a voltmeter for any E.M.F. between 1 and 16 volts. Another type of mercury ammeter may be prepared by making the current pass through a metallic deposit on the bulb of the thermometer tube. E. E. F.

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119. *Action of Induction-coil Condenser.* **A. G. Dell.** (Elect. Rev. N.Y. 33. p. 124, 1898.)—This is a description of some

rough experiments to determine the current, if any, passing between the condenser terminals of an induction-coil and the respective contacts of the make and break apparatus. The experiments, so far as they go, yield no positive results, but they suggest a very useful research. R. A.

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120. *High-Frequency Induction Coil.* **W. P. Boynton.** (Phys. Rev. 7. pp. 35-63, 1898.)—In the work here described the author has endeavoured to verify experimentally the agreement between the actual behaviour of the high frequency induction coil and the results of the approximate theory of an oscillating system with two degrees of freedom. The secondary circuit was used open, *i.e.*, closed by a capacity, and, secondly, closed by a resistance. The frequency used was of the order half a million per second. The primary and secondary potential differences range up to 24,500 volts and 53,700 volts respectively. The chief conclusions may be summarised as follows: (1) The main period of oscillation of the primary circuit is very nearly that deduced from the dimensions of the system. The same agreement is observed in maximum potential attained in the secondary circuit. (2) The effective currents and potentials appear to indicate that the resistances of the sparks are of the order 10 to 100 ohms, depending on the current flowing through the sparks.
E. H. B.

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121. *Pressure of an Induction Coil.* **A. Oberbeck.** (Wied. Annalen, 64. 2. pp. 193–216, 1898.)—In continuation of his previous researches (see 1898, Abstract No. 53), the author has traced some peculiarities of positive and negative discharges as regards electrodes of various shapes. When the electrodes are two spheres the slope of the potential gradient decreases with increasing distance apart, until at 10 cm. the potential remains constant at 30,000 volts for some distance. In the case of blunt points the same thing happens at 7 cm., with 20,000 volts. Afterwards the potentials increase simply with the distances apart. When two points are used, and one of them is put to earth, the negative discharge potential increases rapidly with the distance, but the positive discharge potential, at first higher than the negative, actually decreases at 5 cm. and passes through a minimum of 48,000 volts, increasing rapidly after that. The brush discharge is the only phenomenon which appears to suggest some explanation. It requires only one point, whereas the spark requires two. When the sparking distance is short, no brush discharge takes place, and there is no difference between positive and negative discharge potential if the charge accumulates slowly. But at greater distances the presence of the brush discharge, whose propagation in air depends upon its sign, produces differences between positive and negative spark discharges. E. E. F.

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122. *Use of Simple Sine Curves in Alternating Current Problems.* **W. G. Rhodes.** (Elect. Rev. 43. pp. 395–396, 1898.)—In this paper it is shown that for most purposes it is always possible to replace the actual curves of periodic electromotive forces and currents by sine curves having the same root mean square values and periodic time corresponding to that of the fundamental of the actual curves.

This result follows from the fact that—

$$\int_{\overline{p}}^{\frac{2\pi}{p}} e^2\,dt \quad , \quad \int_{\overline{p}}^{\frac{2\pi}{p}} i^2\,dt \quad \text{and}$$

$$\frac{p}{2\pi}\int_{0}^{\frac{2\pi}{p}} ei\,dt$$

are all independent of the relative phase positions of fundamental and harmonics, when e and i are taken to have the most general form, viz. :—

$$e = e_1 \sin(pt + \alpha_1) + e_2 \sin(2\,pt + \alpha_2) + \ldots + e_n \sin(n\,pt + \alpha_n)$$
$$i = i_1 \sin(pt + \beta_1) + i_2 \sin(2\,pt + \beta_2) + \ldots + i_n \sin(n\,pt + \beta_n)$$

and $p = 2\pi \times$ frequency of the fundamental. AUTHOR.

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123. *Graphical Study of Alternate Currents.* **C. E. Guye.** (Écl. Électr. 16. pp. 397–405, 1898.) (See 1898 Abstracts, Nos. 524, 796, and 1162.)—The author concludes his series of articles by considering the graphical solution of problems relating to: (1) circuits containing resistance, inductance, and capacity, but without mutual inductance; (2) ditto with mutual inductance; (3) circuits containing several impressed E.M.F.'s. The treatment is very systematic, the author in each case giving—(*a*) a diagram of the circuit; (*b*) the equations relating to it; (*c*) the vector diagram containing the solution of the problem. A. H.

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124. *Alternating Currents in Branching Circuits.* **H. T. Eddy.** (Amer. Instit. Elect. Engin. 15. pp. 511–554, 1898.)—When an alternating potential difference E sin pt of frequency n is applied between the terminals of a circuit of resistance R and self-induction L, the current i is given by

$$i = \frac{\mathrm{E}\sin(pt-\delta)}{\sqrt{\mathrm{R}^2 + p^2\,\mathrm{L}^2}}$$

Where $\tan\delta = \dfrac{p\,\mathrm{L}}{\mathrm{R}}$

This can be written

$$i = \frac{E}{R} \cdot \frac{\sin (pt - \delta)}{\sqrt{1 + \tan^2 \delta}}$$

$$= \frac{E \cos \delta}{R} \cdot \sin (pt - \delta)$$

If the circuit contains a capacity C instead of self-induction the current is given by

$$i = \frac{E}{R} \cos \phi \sin (pt + \phi)$$

where

$$\tan \phi = \frac{1}{p\,CR}$$

If R is kept constant while δ and ϕ are varied, the loci of the extremities of the current vector will be semi-circles having diameters equal to $\frac{E}{R}$.

The author regards tan δ and tan ϕ as a kind of co-ordinates and thereby investigates graphically the properties of split circuits. Series of semicircles are drawn for different values of tan δ and tan ϕ from o to infinity, and their points of intersection give the position of the currect vector for the value of these co-ordinates given by their intersection. W. G. R.

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125. *Rectification of Alternating Currents.* **P. Janet.** (Comptes Rendus, 126. pp. 1785–1788, 1898.)—The author discusses the problem: Given a Gramme ring provided with a collector and two brushes, but without inductors: two diametrically opposite points of the ring are fed from an alternating source of frequency n, and of constant effective value; the ring being brought into synchronism by means of an auxiliary motor, what will be the nature of the supply at the brushes? G. B. M.

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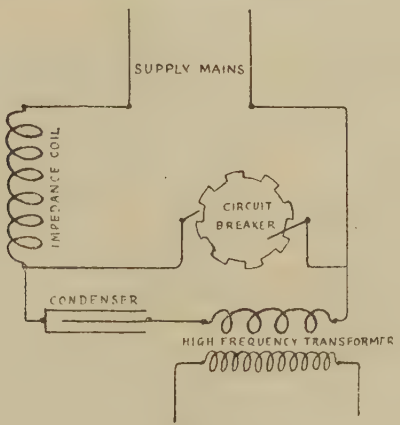
126. *Tesla's Circuit Interrupters.* (Elect. World, 32. pp. 181–184, 1898.)—A fully illustrated description of the devices recently patented by Tesla for producing rapidly oscillating currents. The arrangement of connections used with these interrupters is shown in the accompanying sketch. The interrupters are suitable for use on either direct or alternating current circuits, and have been designed with a view to the highest possible efficiency. The interrupter is in all cases driven by a motor, and the make and break take place either between mercury and a solid conducting terminal, or else between two jets of

mercury. One example of the first type consists of a hollow cylindrical vessel mounted on a horizontal axis, and containing some mercury and oil. This is driven at a very high speed, the liquids being carried round and forming two rings, an outer one of mercury and an inner one of oil. A small star-wheel (whose axis is fixed) is driven round by the rotating liquid rings, the teeth of the wheel alternately dipping into and being withdrawn from the mercury, while the arcs are extinguished by



the oil. A very high make-and-break frequency is thereby attainable. In the other devices described, the main object has been to minimise the waste of energy due to sparking. This is accomplished by introducing, in various ways, into the break chamber, fluids (*e.g.*, anhydrous ammonia) under great pressure. The spark is thereby said to be prevented from spreading laterally, and to be quickly extinguished. A. H.

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127. *Alternating Current Curve Tracer.* **H. L. Callendar.** (Electrician, 41. pp. 582–586, 1898.)—A descriptive account of an instrument for tracing automatically a continuous pen-and-ink curve representing the cyclical variation of the quantity to be recorded. The apparatus consists essentially of a recording potentiometer working in conjunction with an instantaneous contact-maker driven by a synchronous motor. A number of sample curves are given exhibiting the capabilities of the instrument. A. H.

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128. *Hysteresis at High Frequencies.* **I. Klemenčič.** (Wien. Akad. Sitzber. 107. pp. 330–360, 1898.)—By passing the oscillatory discharge from a condenser through magnetising

coils which enclose iron, and observing the decrement of the discharge by intermittent contacts, the author proves that with iron possessing a low coercive force (up to 5 or 6), the hysteresis loss per cycle is distinctly greater with high frequencies than with low. The approximate formula employed gives too low a value for the losses, and the author *has no reliance* on the results obtained with specimens of iron possessing a higher coercive force (16), which indicate a diminution in the losses with higher frequencies. A. Gs.

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129. *Energy Dissipated in Magnetisation.* **C. Maurain.** (Journ. de Physique, 7. pp. 461–466, 1898.)—The author investigates the energy expended in a complete cycle of magnetisation at different frequencies on cores of solid iron and cores made of bundles of iron wire of various thicknesses. The iron core is in the form of an anchor-ring. The closed area in the B-H curve, which measures losses due to hysteresis and Foucault currents, is nearly oval in the case of the solid core, and diminishes in area as the frequency is increased; this is due to the shielding effect of the induced currents, so that the energy dissipated in the interior of the core will be less. As the core is more and more divided up, the shape of the closed area approaches more nearly to the well-known form of the B-H curve for soft iron, and its area diminishes less and less for higher frequencies. In the case of the smallest sub-division of the core, the wires of which it is composed being 0·2 mm., the shape is that of the well-known form and the area is practically the same between frequencies of 23·65 and 55. In all the curves obtained the author found that the maximum of the induction lagged behind that of the current; this lag is greater the less divided the core, a fact easily explained by the action of the induced currents. The lag appears, however, in the case of the most divided core, and the author regards it as a true lag of the magnetisation behind the exciting field, independent of the action of the induced currents. E. C. R.

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130. *Magnetic Screening.* **C. Maurain.** (Écl. Électr. 15. pp. 177–179, 1898.) (Compare Abstract No. 793, 1898.)—The theory of the action of electromagnetic screens made of magnetic materials is complicated by the variation of the magnetic permeability with the intensity of the field. The behaviour of such screens is, however, in general terms as follows: A screen of magnetic material will have a greater effect than a non-magnetic screen of equal conductivity. The frequency of alternation remaining constant, the effect will at first increase with the intensity of the field; after passing the point at which the permeability of the screen is a maximum, the action will again diminish. The author's experiments, made in the way previously

described, show these deductions to be correct. The screening action also increases as the frequency of alternation of the current increases. T. E.

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131. *Magnetic Susceptibility of Liquids.* **G. Jäger** and **S. Meyer.** (Wien. Akad. Sitzber. 107. pp. 5–13, 1898.) Further experiments are made in order to determine whether the atomic susceptibility of chromium in solutions of its salts is exactly 3, those of nickel and cobalt being 2 and 4 respectively. Measurements with chromic chloride and sulphate give 2·5. The salts behave otherwise in the same way as those previously examined. Solutions of ferrous chloride are also used; in them the atomic susceptibility of iron is 3. (Cf. Abstract No. 664, 1898.) T. E.

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132. *Aged Magnets.* **A. Durward.** (Amer. Journ. Sci. 5. pp. 245–256, 1898.)—The author determined the temperature coefficients of the magnetic moments of a large number of magnets aged by the method of Barus and Strouhal. With very few exceptions, all the magnets tested had distinctly greater temperature coefficients at higher than at lower temperatures, between the limits of 15° and 100°. Many of the magnets showed abnormally high coefficients due to local softness. The following table gives the length L in cm., the outside diameter D and the inside diameter *d* in cm., and the mean loss *m* of the magnetic moment per degree Centigrade, for tubular magnets of crescent polished drill rod—

L	D	*d*	*m*
6	0·95	0·70	0·00087
7	0·95	0·70	0·00075
7·5	1·28	0·94	0·00063
10	1·28	0·94	0·00061

E. E. F.

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133. *Constancy of Magnetised Bars.* **Mme. Sklodowska-Curie.** (Bull. Soc. d'Encouragement, série 2. t. 3. p. 63, also Écl. Électr. 16. pp. 117–126, 1898.)—The authoress has experimented on—(1) The action of shocks and jars; (2) the action of variations in the surrounding temperature; (3) the action of magnetic fields produced by magnets or neighbouring currents; (4) the effect of time. The paper deals very thoroughly with the above, but does not well admit of an abstract. E. C. R.

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134. *Magnetic Properties of Tempered Steel.* **Mme. Sklodowska-Curie.** (Bull. Soc. d'Encouragement, série 5. t. 3. p. 58, also Écl. Électr. 16. pp. 151–155, 1898.)—The authoress gives the I-H curves of five steels from the steel manufactory of Firminy having increasing percentages of carbon, a carbon steel of Unieux,

Allevard steel, a tungsten steel, a steel with 3 per cent. nickel, a steel with 0·7 per cent. manganese. An examination of the curves shows that the introduction of different metals slightly modifies the residual intensity of magnetisation in a closed magnetic circuit; it augments the coercive field and the hysteresis, and diminishes the maximum intensity of magnetisation induced. The curves were obtained with values of H between $\pm$ 500. E. C. R.

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135. *Measurement of the Changes produced in Metals by Magnetisation.* **J. S. Stevens.** (Phys. Rev. 7. pp. 19–26, 1898.)—A slightly modified "interferometer" is employed. The mirror frame, which is commonly attached to the movable bed, is removed and firmly screwed to the end of the iron or steel rod to be tested. The other end of the rod is made fast to a brass cylinder, which can be moved backwards and forwards by a micrometer screw. The magnetising coil surrounding the rod is supported independently. In the preliminary experiments rods 30·5 cms. in length and 0·953 cm. diameter were employed. By the interference method, changes which might occur in a rod other than expansion or contraction may be noted. For example, if the rod is distorted the effect is very clearly seen. If the distortion is the result of horizontal planes slipping past each other in a direction parallel to the length of the rod, the mirror will move as if rotated round a horizontal axis. In this case the fringes, which formerly appeared vertical, become inclined at an angle depending on the amount of the distortion. If the distortion is caused by the slipping of vertical planes, the fringes approach or recede from each other. The first effect was quite noticeable in the case of soft iron, but did not appear in steel or nickel. The second was suspected in several cases, but was more difficult to detect. Aluminium, copper, and brass gave no results that could be detected. Nickel showed a contraction for values of H between 5·5 and 38·5 of $\lambda/4$, iron an expansion of from 0·02 λ to 0·5 λ, λ being the wave-length of sodium light. The experiments were then repeated under more favourable conditions on a soft iron rod. Length of rod 75·5 cms., diameter 0·6 cm. Magnetising coil, length 84·8 cms., external diameter 9 cms., internal diameter 4·7 cms.

H	B	δt	$\delta l/l$
102·5	23173·1	$13{\cdot}37 \times 10^{-5}$ cm.	$17{\cdot}7 \times 10^{-7}$
41·0	14537·2	6·75	8·9
20·5	10249·1	4·66	6·2
12·8	7813·9	2·42	3·2
9·3	6430·3	1·55	2·1
5·7	5626·1	1·18	1·6
4·7	5210·3	1·11	1·5

E. C. R.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

136. *Molecular Weights of Liquids.* **C. L. Speyers.** (Journ. Phys. Chem. 2. pp. 347–361 and 362–363, 1898.)—The molecular weights of various liquids in mixtures are calculated from the reduction of the vapour pressure of the constituents, observed by Linebarger and Raoult. The results are held to show both association and dissociation. From the equality of vapour pressure of the two phases in equilibrium, of two liquids not miscible in all proportions, a difference in molecular association is inferred. B. B. T.

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137. *Diffusion of Sulphides through Steel.* **E. D. Campbell.** (Indus. and Iron, 25. p. 230, 1898.)—The author, in conjunction with C. Sundström, has repeated his experiments which J. E. Stead had doubted. A hole was drilled in a Bessemer steel bar, filled with a mixture of oxysulphide of iron (containing manganese) and cuprous sulphide, and plugged with steel; the bar was placed on asbestos and heated to a little above 1200° C. for three hours, air having access. Subsequent determinations of the copper in the steel, in the heavy scale forming on it, and in the asbestos prove that the sulphide had diffused through the steel, which retained about 5 per cent. of the total copper, into the scale and chiefly into the asbestos, which contained 87 per cent. of the copper. The diffusion was less complete when air was excluded from the interior of the furnace, in which lumps of charcoal had been placed. The sulphur of the sulphides is apparently burned. The hole should be treated with hydrochloric acid for an hour previous to being charged; if it is left smooth, the diffusion is slight. The temperature must rise above 1200° C. Stead was thus right in assuming that a great deal depended upon the conditions of the experiments. H. B.

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138. *Solubility of the Carvoximes.* **H. Goldschmidt** and **H. C. Cooper.** (Zeitschr. Phys. Chem. 26. pp. 711–718, 1898.)—In order to test the suggestion that the right- and left-handed modifications of an optically active substance may be unequally soluble in an active solvent, the authors have determined the solubilities of *r*- and *l*-carvoximes in *r*-limonene at different temperatures. The two solubility curves are found to be identical. Again, if the racemic compound of the two carvoximes exists in the liquid state the solubility of the fused mixture of *r*- and *l*- carvoximes should be smaller than that of the pure active modifications. Using a mixture of water and alcohol as solvent no difference in these solubilities could be

detected. In presence of aqueous alcohol the carvoximes melt at a temperature some 20° below their ordinary melting points owing to the solubility of water in the fused substances. T. E.

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139. *Supposed New Atmospheric Gas.* **O. Neovius.** (Wied. Annalen, 66. 1. pp. 162–169, 1898.)—After eliminating all spectrum lines due to electrode matter, the author catalogued the lines due to nitrogen and argon as they appear at atmospheric pressure. He then found some fifteen lines which were common to the blue argon spectrum and to the nitrogen spectrum, the brightest of them being at 4379, 4401, 4430, 4545, and 4736. They are somewhat fainter in the nitrogen spectrum. The author supposes that they are due to an unknown gas which remains as an impurity in the preparation of argon, and also, but to a lesser extent, in the preparation of nitrogen. The spectrum of the supposed new element shows a single coincidence with that of crypton at 4736. E. E. F.

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140. *Physical Effects of Light.* **M. Roloff.** (Zeitschr. Phys. Chem. 26. 2. pp. 337–361, 1898.)—The physical effects of light may be classified under the two heads of modification of the order of the atoms in the molecule, and of the mutual position of the molecules. The former is noticed in various acids, where forms like malic acid are converted into the corresponding forms, such as fumaric acid, under the influence of light. In these changes the two halves of the molecule, connected by a double link, are turned through an angle of 180° with respect to each other. The original form is always the more easily soluble, and has the lower melting and boiling points. As regards polymerisation, it may be said that light produces new combinations between the molecules wherever double links exist. The colourations of salts by kathode rays are intimately associated with the phosphorescence phenomena of fluorspar, calcspar, and other minerals. E. E. F.

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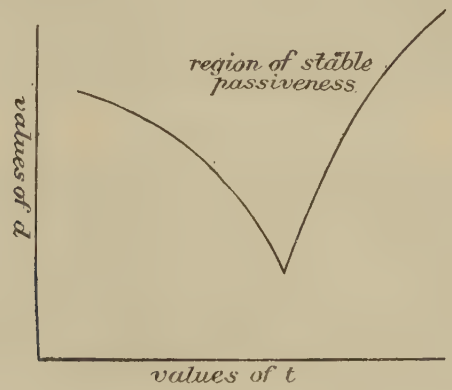
141. *Passive State of Iron and Steel.* **L. Houllevigue.** (Journ. de Physique, 7. pp. 468–469, 1898.)—When iron and steel, previously rendered passive by concentrated acid, is plunged into nitric acid of density d, there exists a certain temperature t, on one side of which the passiveness is stable, while on the other it is unstable, that is to say it can be destroyed by the contact of a copper wire or the passage of an electric current; t may be called the critical temperature. Plotting values of d as ordinates, and t as abscissæ, a curve is obtained which is

characteristic of the kind of iron or steel used. The form of curve is as follows :—



It is seen that for the same density there are two temperatures such that the passive state is only stable between them. The reaction, at the higher temperature at which the passive state ceases, gives, throughout the liquid, rutilant vapours, while the bubbles which are formed at the lower temperature at the contact between metal and liquid are colourless, and are doubtless monoxide or dioxide of nitrogen. E. C. R.

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142. *Vapour Pressures of Hydrated Salts.* **W. Müller-Erzbach.** (Wien. Akad. Sitzber. 107. pp. 14–19, 1898.)—Small quantities of the salt are exposed, at constant temperature, to an atmosphere saturated with water vapour given off by mixtures of sulphuric acid and water of known vapour pressure. The samples are weighed at intervals of a day. In this way an acid is readily found in presence of which the salt does not change in weight. The vapour pressure of the salt may be determined in this way with an error of less than 1/50 mm. of mercury. The experimental work was carried out with Glauber's salt at the ordinary temperature. T. E.

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143. *Freezing-Points of Dilute Solutions.* **C. Dieterrici.** (Wied. Annalen, 64. 4. pp. 809–810, 1898.)—A reply to R. Abegg's criticism. Annal. Phys. Chem. 64. p. 486–506, 1898, of author's paper, Annal. Phys. Chem. 62. p. 616–643 (1897). B. B. T.

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144. *Structure of Crystals.* **W. J. Sollas.** (Roy. Soc. Proc. 63. pp. 270–300, 1898.)—This paper consists of a study of the molecular tactics of crystals of the cubic system with cubic cleavage. The author assigns an open packing to the metals crystallising in the cubic system, and points out that the absorption of hydrogen by palladium is strong confirmatory evidence of this view. S. R.

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145. *Crystallisation—Velocity II.* **G. Tammann.** (Zeitschr. Phys. Chem. 26. 2. pp. 307–316, 1898; see also 23. p. 326, 1897.)—The author replies to F. W. Küster (Zeitschr. Phys. Chem. 25. 480–482, 1898), and develops the phenomena of crystallisation at different degrees of undercooling more fully. The effect of pressure is found to be a slight diminution of the velocity (4 to 7 per cent. per 300 atm.). The behaviour of crystals and the proportion of unsolidified liquid remaining between them, are discussed. B. B. T.

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146. *Chemical Applications of the Electric Arc.* **Bredig.** (Zeitschr. Elektrochem. 4. pp. 514–515, 1898.)—By means of the electric discharge between carbon points under petroleum an illuminating gas is produced which contains 30 per cent. of heavy carburetted hydrogen, and 6–8 per cent. acetylene. If an electric arc is made from metal wires under pure water, the wires of zinc, silver, platinum, &c., are pulverised into an extremely fine suspension of those metals in water. So that obscure liquids are produced, which, especially in the case of the noble metals, go through the filter coloured, and in particular in the case of platinum often do not become clear for weeks. Tichomiroff and Lidoff have already described this pulverisation in the case of zinc. They conclude that the metallic vapours of the arc in the surrounding cold water immediately become condensed as mist, and through instantaneous chilling remain kept from uniting together. Thus very finely divided platinum which exhibits catalytic action, can be produced from platinum wire with the help of the arc without a chemical reducing medium. J. J. S.

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147. *Migration Constant of Hydrogen.* **D. McIntosh.** (Journ. Phys. Chem., 2. pp. 273–288, 1898.)—The migration constant of an ion can be obtained either by Hittorf's direct method of analysis, or by Helmholtz's method from observations on the E.M.F. of a concentration cell. The author seeks to apply Helmholtz's method to Grove's gas cell. He uses hydrogen over different concentrations of various acids arranged for diffusion and without diffusion. Chlorine, bromine, and iodine cells are also investigated.

The general conclusions are :—

1. The Helmholtz method is not applicable to gas cells.

2. The source of error is probably in the solubility of the electrode (platinised platinum).

3. It is probable that the migration constant for hydrogen does not change with dilution between normal and thousandth-normal solutions. S. S.

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148. *Migration Constants for Zinc and Cadmium Salts.* **G. Kümmell.** (Wied. Annalen, 64. 4. pp. 655–679, 1898.)—The author finds the following values for the negative ion in dilutions from 1/100 to 1/400 normal. $ZnCl_2$ 0·60 : $ZnBr_2$ 0·60 : ZnI_2 0·59 : $CdCl_2$ 0·58 : $CdBr_2$ 0·58 : CdI_2 0·55. These salts give quantitative deposits of the metal when air is excluded and pure water used. The evolution of hydrogen and separation of hydroxide, which is often observed in dilute solutions, is shown to be due to alkali abstracted from the glass ; but even here the total amount of metal in the deposit and hydroxide obeys Faraday's law. The values for $ZnCl_2$ and $CdCl_2$ agree with those determined indirectly from the E.M.F. of the combinations—

$$M - MCl_2\ 0{\cdot}1\ \text{normal} - M\ Cl_2\ 0{\cdot}01\ \text{normal} - M$$

and—

$$Hg - HgCl - MCl_2\ 0{\cdot}1\ \text{normal} - MCl_2\ 0{\cdot}01\ \text{normal} - HgCl - Hg$$

of which the first is proportional to n, the second to $(1-n)$. Comparison of the conductivity at infinite dilution ($\lambda_\infty = u+v$) calculated from the above on the assumption that the mobility of the negative ions is the same as in their alkali salts, with that directly observed, shows that except in the case of CdI_2 the limiting transportation values have probably been reached.

In the electrolysis of the sulphates a flocculent deposit is always observed, and Faraday's law is not obeyed. This is due to a secondary action of the salt on the metal forming basic sulphate. When the amount of SO_4 in the precipitate is determined, and the corresponding amount of metal deducted, the total electrolytic deposit is found to satisfy the law. For $CdSO_4$, the author finds $n = 0{\cdot}62$ agreeing with the value from the concentration cells, but for $ZnSO_4$ 0·66 differing greatly from the indirectly determined value 0·59 : this probably indicates the existence of complex ions as $Zn(SO_4)_2$. The calculated conductivity for infinite dilution also does not agree with the observed value. B. B. T.

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149. *Ionisation determined by means of Conductivity.* **A. A. Noyes.** (Zeitschr. Phys. Chem. 26. pp. 699–710, 1898.)—The heat of solution of a salt dissociating into two ions in accordance

with the dilution formula of Rudolphi and van't Hoff is given by van Laar as $q = RT^2\ 3/(3-\alpha)\ \frac{d \log s}{d T}$, where s is the solubility and α the degree of dissociation. Independently of any dilution law, the value for $\alpha = 1$ must be $q = 2RT^2\ d \log s/dT$, which does not agree with van Laar's equation. By means of a reversible cycle, the following equation (first given by van't Hoff) is deduced; $q = RT^2\ i\ d \log i s/dT$. For an electrolyte dissociating into n ions and following a dilution law of the form $K = (\alpha s)\gamma / (1-\alpha)\ s$. This gives—

$$q = RT^2 \left(\frac{\gamma + (n-\gamma)\alpha}{\gamma - (\gamma-1)\alpha} \frac{d \log s}{d T} + \frac{(n-1)\ \alpha\ (1-\alpha)}{\gamma - (\gamma-1)\ \alpha} \frac{d \log K}{d T} \right).$$

When α is approximately unity (salts), or zero (weak acids and bases), the second term tends to vanish. Neglecting it we obtain for $\gamma = 2$ and $n = 2$ (Ostwald's dilution law) $q = RT^2\ 2/2-\alpha\ d \log s/dT$ . . . (1), and for $\gamma = 3/2$ and $n = 2$ (van't Hoff's dilution law) $q = RT^2\ (3+\alpha)\ (3-\alpha)\ d \log s/dT$ . . . (2). The values of q calculated from equation (1) for a weak acid and from (2) for some salts agree very well with those experimentally obtained. Van Laar's equation gives wide divergence to explain which he assumed that the values for the dissociation obtained from the conductivity are incorrect. He supported this view by the fact that solutions of hydrochloric acid in aqueous alcohol and in water, equally dissociated according to conductivity measurements, invert cane sugar with different velocities. This is, however, due to the different concentrations of the water. His hypothesis that the dissociation is affected by the heating effect of the current used in measuring it is not compatible with the fact that the conductivity is independent of the strength of current. Finally, dissociations measured by freezing-point experiments, and by solubilities of mixtures of salts, agree well with those measured electrically. T. E.

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150. *Electrolytic Preparation of Glucinum.* **P. Lebeau.** (Comptes Rendus, 126. pp. 744–746, 1898.)—Glucinum may be obtained in a pure state by the electrolysis of the double fluoride of glucinum and sodium which is a conductor. The process was carried out in a nickel crucible which served as negative electrode, the positive one being a plate of graphitic charcoal. The metal was obtained in the form of a powder consisting of irregular crystals of pure glucinum. Under the microscope it is a brilliant metallic white colour, and contains no trace of amorphous matter. J. J. S.

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151. *Electrolysis of Zinc Chloride Solutions: the Nature of Zinc Sponge.* **F. Foerster** and **O. Günther.** (Zeitschr. Elektrochem. 5. pp. 16–23, 1898.)—Experiments were made on the electrolysis of zinc chloride solutions, from which cadmium and other more electronegative metals had been removed by precipitation with metallic zinc, and the neutrality, acidity or alkalinity of which was carefully controlled by analysis. The anodes consisted of electrolytic zinc, containing traces only of lead and iron, and the kathodes of ordinary zinc plate. The solutions were kept in continual agitation by a mechanical stirrer. In the case of neutral solutions, a deposit of fine, smooth zinc was first obtained, but sooner or later a spongy mass was formed, and the solution became turbid from precipitation of basic zinc chloride. This was not prevented by the action of chlorine produced electrolytically in the solution by a current of 0·1 to 0·2 ampere between platinum anodes and the kathode of the principal current. Excellent results were obtained, however, in solutions acidified with hydrochloric acid to 1/20–1/30 of the normal strength, together with the slow and continuous liberation of chlorine as above described. Instead of chlorine, a current of air may be employed, but in that case, owing to the rapid oxidation of the zinc, the free acid in the solution is more quickly neutralised, and fresh additions have frequently to be made. It was to be expected that the electrodeposition of zinc might be effected in alkaline solutions, if only the solubility of zinc oxide therein could be sufficiently increased by raising the temperature and the concentration. This was found to be the case; electrolysis at 60° gave unsatisfactory results, but fine crystalline deposits were obtained at 90–100° with 40 per cent. solutions of zinc chloride saturated with zinc oxide. It has been stated by Ashcroft that in the electrolysis of such hot alkaline solutions, using insoluble anodes, a far greater amount of zinc was deposited than that accounted for by Faraday's law. A number of experiments made with a copper voltameter included in the circuit were not confirmatory of this statement, the metal deposited being always somewhat less than the theoretical amount. The deficiency is attributed to secondary reactions, the chlorine liberated at the anode reacting with the zinc oxide to form zinc hypochlorite which then suffers reduction at the kathode.

The observations of the authors are in harmony with the received opinion that the spongy deposit of zinc is formed in neutral or slightly alkaline solutions, when the hydrogen ions are liberated in such quantity that the simultaneous concentration of hydroxyl ions in the region of the kathode lead to the formation of zinc hydroxide or basic zinc salts. The formation of the sponge is favoured, as might be expected, (1) by too dilute solutions, (2) by the presence of metals more electronegative than zinc, (3) by gas-bubbles on the kathode, which hinder diffusion of the liquid and cause an irregular deposition of metal. The concentration of hydroxyl ions and the consequent pro-

duction of sponge is effectually prevented by the presence of free acids. It is to be observed that the acidity of the liquid in the immediate vicinity of the kathode is the essential condition to be fulfilled; hence the need of continual renewal of the liquid at this point by constant agitation. Neutral oxidising agents favour the production of spongy zinc so long as they do not increase the concentration of the hydrogen ions; otherwise they hinder it. To the first class of substances belong hydrogen peroxide and ammonium nitrate; to the second, chlorine and ammonium persulphate. Potassium permanganate is an effectual preventative in neutral solution, although its action leads to the production of hydroxyl ions; its efficiency is due, however, to the carrying down of zinc oxide with the precipitated manganese peroxide. J. W.

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152. *Electrolytic determination of Tin in Tin Ores.* **E. D. Campbell** and **E. C. Champion.** (Indus. and Iron, 25. pp. 267–268, 1898.)—A description of a modified form of Classen's double oxalate method. One gramme of the finely ground ore is intimately mixed with 5–6 grms. of the sodium carbonate and sulphur fusing mixture, and is fused at a full red heat for one hour. The porcelain crucible containing the ore is placed within a large one to lessen risk of oxidation, and this again is covered by an inverted Hessian crucible during fusion in order to obtain uniform heating.

After cooling, the soluble tin salt is dissolved out by treating with 40–50 c.c. of hot water; the residue is washed, dried, ignited, and again fused with the mixture in the same crucible, in order to extract the last traces of the tin. Hydrochloric acid is added to the united solutions till slightly acid, and stannic sulphide is precipitated; and the solution is boiled down to drive off sulphuretted hydrogen and to reduce its volume to between 75 and 80 c.c. Ten ccms. hydrochloric acid (1·20 sp. gr.) are now added to the hot solution, and from 2–3 grammes sodium peroxide are added little by little until the tin has been wholly converted into stannic chloride. The solution is now boiled again to cause the sulphur to collect, and it is then filtered into a platinum dish. Ammonium hydrate is added until a slight permanent precipitate has formed, and then 50 c.c. of a 10 per cent. solution of acid ammonium oxalate. The solution should now be clear. It is electrolysed with a current of ·10 ampere at 4 volts, and may be left overnight for deposition of the tin. The latter will be found as a white metallic deposit, firmly adherent to the platinum dish. The determination is completed in the usual manner. The authors recommend the carrying out of dual determinations under precisely similar conditions, and the use of a platinum dish as counterpoise in weighing.

J. B. C. K.

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153. *Electrolytic Indigo-Vats.* **A. Binz.** (Zeitschr. Elektrochem. 5. pp. 5–9, 1898.)—The reduction of indigo-blue to indigo-white is in practice effected by zinc dust in presence of caustic soda, the reaction taking place easily at the ordinary temperature. Attempts to effect the reduction by means of the hydrogen evolved at the kathode in the electrolysis of caustic soda solution have shown that the reaction is very incomplete unless the liquid is raised to the boiling temperature, and that if the action of the current be too long continued the indigo-white is destroyed and rendered useless. In the course of an investigation of the most favourable proportions of zinc and alkali for the reduction of indigo, the author found that a solution of caustic soda, so dilute as to have scarcely any action on zinc, was yet sufficiently effective to take part in the reduction of a considerable quantity of indigo. It was found, moreover, that when a zinc anode and platinum kathode were placed in two vessels, filled with alkaline indigo solution, connected by a syphon, and joined up in circuit with a battery and a copper voltameter, that reduction took place at the anode, where no hydrogen could be evolved, and that the loss in weight of the zinc anode was greater than that corresponding with the copper deposited in the voltameter. The zinc in this experiment was amalgamated, and in the absence of indigo it was found that the loss in weight of the zinc was strictly in accordance with Faraday's law. It would appear, therefore, that the reduction of the indigo is brought about by direct action of the zinc, and not by the hydrogen evolved by the action of the metal on the alkali. The latter serves the purpose of keeping in solution the zinc oxide which, if the alkali is too dilute, encrusts the anode and prevents further action. J. W.

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154. *Formation of Indigo-white by Galvanically Deposited Zinc.* **A. Binz.** (Zeitschr. Elektrochem. 5. pp. 103–108, 1898.)—This paper deals with the reduction of indigo-blue to indigo-white by means of an alkaline zinc bath and the application of the current. The author shows that electrolytic hydrogen has only a very slight and incomplete action upon indigo-blue, but that zinc deposited by the current brings about an almost theoretical conversion. A series of experiments are here given which prove that the zinc deposited converted fifteen times as much blue into white as the equivalent of hydrogen set free by the same current. O. J. S.

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155. *Siemens and Halske Process in the Transvaal.* **H. Pauli.** (Zeitschr. Elektrochem. 5. pp. 101–103, 1898.)—This paper is an historical account of the development and growth of the Siemens-Halske electrolytic cyanide gold extraction process. The author gives some thirty mines where the Siemens process is at work,

and states that in the case of poor solution it is superior to the original MacArthur, and it also has the further advantage that the gold bullion is free from zinc. The royalty charged is 2 per cent. O. J. S.

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156. *Regenerative Electro-Zincing.* (Indus. and Iron, 25. pp. 268–269, 1898.)—This paper gives a short illustrated description of the Cowper-Coles process of electrogalvanising Belleville boiler tubes both inside and outside. It describes the method of regenerating the zinc sulphate solution by means of zinc dust, and includes sectional drawings showing the disposition of the plant. J. L. F. V.

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157. *Calcium Carbide Works at Ingleton.* **F. J. A. Matthews.** (Electrician, 41. pp. 643–645, 1898.)—This paper gives an outline of the latest practice in the manufacture of calcium carbide under Raoul Pictet's patents as illustrated by their first practical application in England. The principle of gradually raising the temperature of the lime and coke mixture by means of the waste heat from the zone of the electric arc is explained, and the furnace is described and illustrated. The novel features of the 120-kilowatt dynamo, which enable it to run with great variation of load, are pointed out.

The carbide made in this furnace yields an average of 5 cubic feet of gas per lb. J. L. F. V.

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158. *Electric Smelting.* **W. S. Horry.** (Elect. World, 31. pp. 784–785, 1898.)—From a sulphide nickel ore containing about 42 per cent. of sulphur combined with iron, nickel and silica, the author obtained by electric smelting a charge containing 40 per cent. nickel, 28 per cent. iron, 12 per cent. carbon, 15 per cent. silicious matter and no sulphur. Nickel in a fair state of purity can be obtained by this process, but as yet no data as to cost are available. E. H. C.-H.

GENERAL ELECTRICAL ENGINEERING.

159. *Accumulator Charging at Constant Pressure and at Constant Current.* **A. A. Cahen** and **J. M. Donaldson.** (Electrician, 41. pp. 674–677 and 710–712, 1898.)—The experiments described in this paper were made with a single 5-plate Tudor cell, formed positives and pasted negatives, listed to give a discharge of 36 amperes for 3 hours and for a normal charging rate of 20 amperes. In the constant potential series of tests the cell was charged at 2·508 volts and the charge continued until the current had dropped to 10 amperes. At starting, the current was as much as 160 to 170 amperes but fell rapidly. In the constant current series the charging current was 20 amperes throughout, until the potential difference had risen to 2·58 volts. In both cases the cell was discharged at 36 amperes until its potential had fallen to 1·815 volts. The variations of current, E.M.F., and specific gravity of the electrolyte during charge and discharge are fully illustrated by curves. The comparison of the results obtained by the two methods showed that at constant potential the cell could be charged in less than half the time and its capacity was about 30 per cent. greater, but on the other hand its ampere-hour efficiency was about 2 per cent. less, and its watt-hour efficiency about 10 per cent. less. As far as the experiments went no conclusions could be drawn as to the relative effects of the two methods of treatment on the life of the cell. E. J. W.

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160. *Ammonium-Chloride Accumulator with Carbon Plates.* **W. M. Stine.** (Amer. Electn. 10. pp. 418–419, 1898.)—This is an account of some experiments made with the above combination in 1891. The storage largely depends on the absorption by the electrodes of the gases liberated on charging, and the best effect was obtained with granular arc-light carbon packed round the plates. The author concludes that although the cell is light and inexpensive to construct it has no commercial value on account of (1) the rapid deterioration of the positive plate, *i.e.*, the anode; (2) the rapid loss of charge on standing; (3) the rapid fall of E.M.F. on discharge, and—(4) the low efficiency.

E. J. W.

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161. *Accumulator Construction.* **D. Fitz-Gerald.** (Elect. Eng. 21. pp. 553–554, 593–594, and 22. pp. 11–13, 70–71, 102–103, 198, and 294–295, 1898.)—Continuation of articles on this subject. EDITOR.

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162. *Solder for Aluminium.* (Électricien, 15. pp. 389–391, 1898.)—A good solder for aluminium is here stated to be an alloy

composed of 70 parts of aluminium, 20 of tin and 10 of copper. This alloy gives perfect and solid joints without any galvanic action. The best flux to use is potassium fluoride. W. G. R.

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163. *Lithin.* (Elektrochem. Zeitschr. 5. pp. 105–106, 1898.)—"Lithin" is the name of a new insulating material, intended as a substitute for ebonite or vulcanised fibre. Sheets of lithin submerged in water for 72 hours, increased in weight by only 0·41 per cent. Tests are given of the dielectric-resistance of various samples, but the details are too few to enable comparisons to be drawn. When connected to the terminals of a transformer, a plate 1·25 mm. thick broke down at 9,300 volts; a plate 10·5 mm. thick withstood 36,000 volts. The Reichanstalt is examining the material. R.A.

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164. *Relative cost of Copper, Aluminium, and Iron as Conductors.* **J. B. C. Kershaw.** (Elect. Rev. 43. p. 331, 1898.) —The writer gives a formula for use in calculating the relative costs of equal lengths of conductors of equal electrical resistance, and then applies it to the calculation of the relative costs of the three metals named above.

Using S for the specific gravity, P for the cost price per lb. and C for the conductivity of copper, and s p c for the corresponding values of the other metal, the formula

$$\frac{S \times P \times c}{s \times p \times C}$$

will be found to give the relative costs of the two metals when used as conductors. Substituting the numerical values for the symbols S P C and s p c, the following ratios are obtained :—

Copper : Aluminium[1]	... ...	101 : 100
Copper : Aluminium[2]	... ...	100 : 135
Copper : Iron	... ...	278 : 100

Calculating these ratios upon Iron = 100, the following table is obtained—

Iron	100
Aluminium[1]	275
Copper	278
Aluminium[2]	375

[1] A. E. Hunt's price for 100 per cent. aluminium in bar form; 29 cents per lb.

[2] Market price for 99 per cent. aluminium in ingot form; 31·7 cents per lb.

AUTHOR.

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165. *Wiring Chart.* **R. L. Ellis.** (Elect. World, 31. p. 778, 1898.)—This chart is designed with the object of graphically calculating feeders and service wires, and lessening the labour entailed; it can be easily used and can be readily constructed to suit the varying conditions occurring in practice.

In any system the lamps are usually all of one efficiency, so that for a given case the current per lamp is a constant. This leaves four variables: loss in volts, number of lamps, distance and cross section. A different chart has to be constructed for lamps of different current consumption. An illustration is given of the above chart where the horizontal scale is marked out in convenient divisions, say up to 200 feet, and the vertical scale to a convenient scale such as 10 volts. Then the drop is calculated for different sizes of wire, say, from No. 2 to No. 14. By drawing suitable diagonals a chart is obtained useful for a given number of lamps at a given efficiency with a variable "drop" and for various sizes of wire. The chart can also be arranged for a variable number of lamps.

L. J. S.

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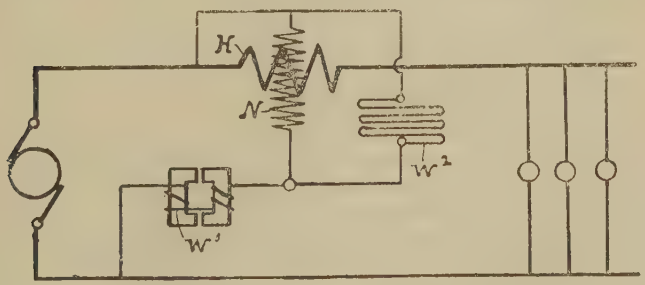
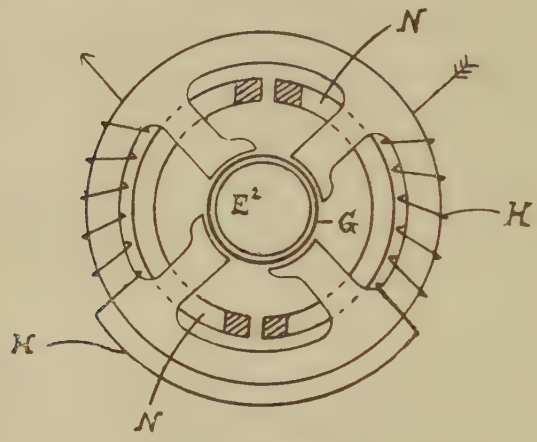
166. *Alternate-Current Meter.* (Elect. Engin. 22. pp. 82–83, 1898.)—This meter, which is being sold by the Electrical Company, Ltd., London, comprises a Ferraris motor working with single-phase alternating-current. The field magnet is made with four similar pole-pieces each having an extension on one side. The series-winding H is of the Gramme type; the shunt-winding N is laid in frames inside the poles, the shunt-current being controlled by an inductive resistance W^1 in series therewith. The



armature is formed of a bell-shaped piece of copper G revolving over a fixed core E_2, and is arranged so that part of its weight is counteracted by the alternating field. It acts against a Foucault brake disc rotating between permanent magnets. The motion of the armature or rotor arbor is transmitted to the counting train by means of a worm and worm-wheel. To make the meter sensitive under a very light load, the armature is adjusted so that it tends to just rotate continuously by the action of the shunt. To prevent the meter from running idle in this manner, a small piece

of iron wire is attached to the brake disc so as to be attracted by the permanent magnets, and is so bent that the meter remains motionless so long as no main current passes through, nevertheless the slightest action of the main current serves to start it: after being switched out of circuit the rotating portion completes one



more revolution until arrested by the action of the permanent magnets on the piece of iron. To measure accurately in inductive circuits, it is necessary that the artificial difference of phase shall amount to exactly 90°. This lag is obtained by arranging a non-inductive resistance W_2 in parallel with the shunt winding of the motor. C. K. F.

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167. *Meters.* (Elect. World, 32. pp. 237–238, 1898.)—Five per cent. accuracy at overloads is more important than at light loads. Slow speeds are advised and the diminution of magnetic damping with heat is noted. Lighter coloured Ceylon sapphires are best for jewels. Jewels succumb to the hammering and not to rotational action, hence the meter must not be fixed on a partition. Shunt meters must not be stopped, but should be kept on the station side of the main switch. Meters may be tested with a box of calibrated lamps. M. O'G.

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168. *Meters.* **H. Armagnat.** (Écl. Électr. 16. pp. 89-93 and 136–139, 1898.)—A number of meters are described. EDITOR.

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169. *Manufacture of Carbons.* **F. Jehl.** (Electrician, 41. pp. 50–52, 177–179, 386–388, 416–419, 580–582, 612–615, and 806–808, 1898.)—A series of articles on this subject. EDITOR.

170. *Standard Threads and Gauges for Screw-Socket Lamp-holders.* **R. Hundhausen.** (Zeitschr. Elektrotechn. Wien, 16. pp. 334–339, 1898; see also E. T. Z., Berlin, Heft 20 and 22.)—The Verband Deutscher Elektrotechniker have carefully considered the question of fixing a standard thread for screw-socket lamp-holders and lamp-caps, and in the two articles referred to above, are given specifications and drawings of the threads on the lamp and in the socket, and also of gauges for examining caps and sockets made in accordance with such standards. In fixing the standards, both German and American practice have been taken into consideration. C. K. F.

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171. *Electrical Heating Apparatus.* **R. B. Ritter.** (Écl. Électr. 16. pp. 450–453, 1898.)—This article describes the various types of electrical heating apparatus for use on alternating current circuits, and mentions that the *Société d'Electricité Alioth* of Bâle have produced such apparatus in which the heat is developed chiefly by eddy currents in large masses of metal so that the conductors carrying current do not get overheated. W. G. R.

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172. *Underground Mains.* **F. Jehl.** (Amer. Electn. 10. pp. 254–261, 1898.)—Descriptive of systems used in Europe.
EDITOR.

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173. *Erection of High-Pressure Lines.* **S. H. Dailey.** (Amer. Electn. 10. pp. 384–385, 1898.)—This is a second article (see 1898, Abstract No. 1095) on the practical details to be attended to in erecting a high voltage transmission line.
W. G. R.

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174. *Reno Inclined Elevator.* (Elect. Engin. N.Y. 26. pp. 1–3, 1898.)—An electric inclined elevator installed at a department store in New York is described and illustrated. The inclined elevator is said to fill the void between a common staircase and a vertical elevator.

Since it has been installed, 50,000 persons have taken advantage of this novel device without any accident. It is $3\frac{1}{2}$ feet in width and is built at an angle of 25 degrees. The moving incline consists of an endless chain rotated by a sprocket wheel to which are attached a number of hard wood slats. These slats have attached to them a series of rubber-covered ridges, each about 3/4″ wide and 1″ high. These ensure a safe landing at the upper end of the machine.

The general and detailed construction of the elevator is shown in illustrations and diagrams. The elevator is geared to a motor

by double reduction gearing, giving a total reduction of 1/36th. The speed of the motor, 450 r.p.m., is thus reduced to about 12 r.p.m. at the chain, which gives the moving incline a speed of 75 feet per minute. The elevator is fitted with a 10 H.P. motor, although the maximum load on the elevator only requires a motor of one-half that capacity. The motor is controlled by an automatic starting box. To the switch of this starting box is attached a cord which leads to the upper and lower ends of the elevator, and by means of which the motor can be started, stopped, or reversed. Another essential feature of the elevator is a moving handrail, travelling at the same speed as the platform.

The elevator, if run continuously for ten hours, will cover about nine miles in one day; and counting one passenger for every two feet, it will carry thirty-seven in one minute, or 2,200 in one hour.

The following table arrived at from a long series of tests, shows the power required for working such an elevator :—

Volts.	Amp.	H.P.	Remarks.
110 ...	8·2 ...	1·2 ...	Elevator free
110 ...	16·0 ...	2·36 ...	5 people on elevator
110 ...	19·0 ...	2·8 ...	9 „ 5′ apart
110 ...	20·0 ...	2·95 ...	11 „ 4′ „
110 ...	35·0 ...	5·15 ...	21 „ 2′ „

Assuming the power to cost 3 cents per H.P. hour it would cost 7 cents to carry 1,000 passengers in one hour.

Among a number of advantages enumerated in favour of this system an important one is that it consumes power only in proportion to the number of passengers carried. L. J. S.

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175 *Measurement of Power.* (Mech. Eng. 1. pp. 473–477, 561–563, 617–620, 688–690, and 2. pp. 119–121, 190–191, 1898.)—A description of various dynamometers and methods of measuring power. EDITOR.

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176. *Shaft Governor.* **T. Hall.** (Elect. World, 31, pp, 678–681, 1898.)—A consideration of the problems involved in governing. EDITOR.

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177. *Oil Fuel.* (Railway World, 7. pp. 105–108, 1898.)—Descriptive of methods and apparatus. EDITOR.

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178 *Thermal Efficiency of Steam Engines.* **Report of the Committee of the Institution of Civil Engineers.** (Electrician, 41. pp. 623–628, 1898).—The report is prefaced

by a note by Captain Sankey showing what it has been desired to measure and to compare. A steam plant in its simplest form consists of (1) the boiler, (2) the steam pipes, (3) the engine. Further, the plant may include (4) a condenser and air-pump, (5) an economiser, (6) a feed-heater, (7) steam jackets. The

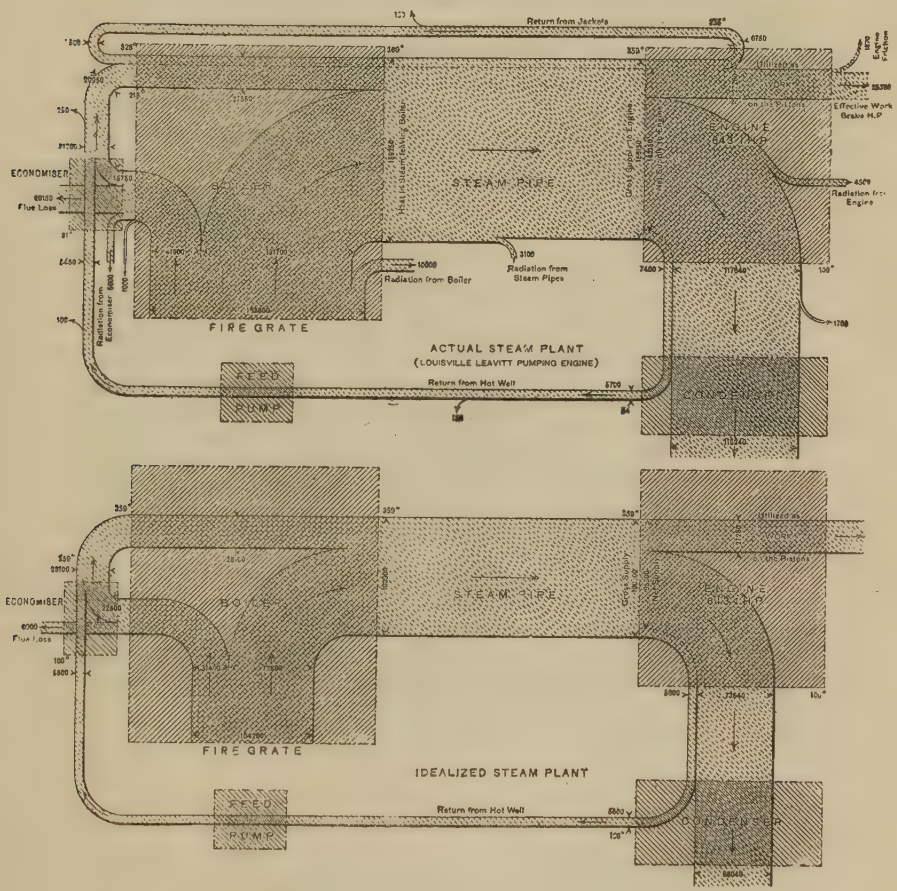

diagram represents the trial of the Louisville Leavitt Pumping Engine, and the flow of heat is stated at all points with fair accuracy. The recommendations of the Committee are:—

1. That "thermal efficiency," as applied to any heat engine, should mean the ratio between the heat utilised as work on the piston by that engine and the heat supplied to it.

2. That the heat utilised be obtained by measuring the indicator diagrams in the usual way.

3. That in the case of a steam engine, the heat supplied be calculated as the total heat of the steam entering the engine less the water-heat of the same weight of water at the temperature of the engine exhaust, both quantities being reckoned from 32° F.

4. That the temperature and pressure limits, both for saturated and superheated steam, be as follows:—

Upper limit: the temperature and pressure close to, but on the boiler side of, the engine stop-valve, except for the purpose of calculating the standard of comparison in cases when the stop-valve is purposely used for reducing the pressure. In such cases the temperature of the steam at the reduced pressure shall be substituted. In the case of saturated steam the temperature corresponding to the pressure can be taken.

Lower limit: the temperature in the exhaust-pipe close to, but outside, the engine. The temperature corresponding to the pressure of the exhaust steam can be taken.

5. That a standard steam engine of comparison be adopted, and that it be the ideal steam engine working on the Rankine cycle between the same temperature and pressure limits as the actual engine to be compared.

6. That the ratio between the thermal efficiency of an actual engine and the thermal efficiency of the corresponding standard steam engine of comparison be called the efficiency ratio.

7. That it is desirable to state the thermal economy of a steam engine in terms of the thermal units required per minute per I.H.P., and that, when possible, the thermal units required per minute per B.H.P. be also stated.

8. That, for scientific purposes, there be also stated the thermal units required per minute per H.P. by the standard engine of comparison, which can readily be obtained from a diagram similar to that given in Fig. 4 of the Report and from which the efficiency ratio can be deduced. A. S.

GENERATORS, MOTORS, AND TRANSFORMERS.

179. *Dynamo Design.* **J. K. Sumec.** (Zeitschr. Elektrotechn. Wien, 16. pp. 454–458 and 469–474, 1898.)—The methods hitherto commonly in vogue for determining the dimensions of a dynamo from its output and speed consist in using a formula (such as those proposed by Esson, Snell, Kapp, and others), connecting output with speed and length and diameter of armature. Such formulæ involve a coefficient depending on the type of machine and (more particularly in the case of alternators) the skill of the designer. The author makes a departure from this time-honoured practice, and proposes the following plan of designing a dynamo. The output of a machine may be expressed by the formula—

$$W = 10^{-8} . v \gamma B k D \pi l,$$

which does not contain any arbitrary coefficients. In this fomula, W = output in watts; v = peripheral speed in cm/sec.; γ = total current, in amperes, per cm. length of armature circumference; B = mean magnetic induction under pole-pieces; k = ratio of width of pole to pitch; D = diameter, and l = length of armature, in cms. In accordance with the conditions under which the machine is to be used, a suitable value of v is assumed; from this, and the known revs. per min., D is at once determined. The values of γ and B are determined by considerations regarding heating; k will depend on the type of machine. The above formula then gives l, and thus the dimensions of the machine are completely determined. When dealing with alternators, the right-hand member of the formula has to be multiplied by half the value of Kapp's coefficient. The author works out, by the above method, the design of a 22·5-kilowatt dynamo, a 150-kilowatt three-phaser, and a 75-H.P. induction motor. The various methods of dealing with armature reaction in dynamos, alternators, and induction motors form the concluding part of a valuable paper. A. H.

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180. *Drum Armature Windings.* **A. L. Rice.** (Amer. Electn. 10. pp. 319–321, 1898.)—The author shows how to wind an armature which was designed for a multiple-circuit winding, so that it shall have a two-circuit winding. He takes as an example a four pole four-circuit armature with 48 conductors, in formed coils laid in slots. In order to convert this to a two-circuit winding, two conductors must be left out; so one end of a coil is disconnected from the commutator and insulated, and the commutator bar to which the other end of this coil is connected is short circuited on to the next commutator bar.

The author also shows how to convert a six pole six circuit winding to a two circuit winding. The paper is illustrated by diagrams. R. B. R.

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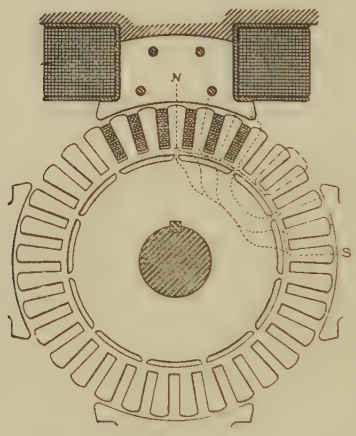
181. *Reduction of Inductance of Armature Coils.* (Elect. World, 32. p. 185, 1898.)—The improvement in the construction of armature cores, illustrated in the accompanying sketch, consists in punching a set of tangential slots immediately underneath the teeth, so as to form a narrow rim in which the induc-



tion is pushed to a very high value. The inductance of the windings is thereby reduced, and sparkless running facilitated. Tests carried out on two armatures of the same size and similarly wound, but having different cores, one of the ordinary and the other of the improved type, showed a reduction in the core losses of the latter which resulted in a 2 per cent. gain in efficiency.

A. H.

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182. *Windings of Multiphase Armatures.* **J. P. Stone.** (Amer. Electn. 10. pp. 367–371, 1898.)—The author states that the object of this paper is to describe a few of the most useful windings of multiphase armatures that are used in American practice.

Illustrated descriptions are given of di-phase and tri-phase non-overlapping and overlapping uni-coil and multi-coil windings.

W. G. R.

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183. *Commutated Current-Wave of Compound-wound Alternator.* **D. C. Jackson.** (Amer Instit. Elect. Engin. 15. pp. 451–456, 1898.)—The author gives some interesting curves showing the commutated current-wave in the series winding of a Thomson-Houston alternator. The curves are (apart from commutation) similar to the external current curves of the machine, except in the neighbourhood of the zero point, the commutated current never reaching a zero value on account of the short-circuiting of the series coils by the brushes on the commutator. Curves are also given of the current in the separate-excitation coils; the pulsations occurring in this current may be accounted for by the rotation of the toothed armature. There does not appear to be any immediate connection between these pulsations and those in the series coils. A. H.

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184. *Induction Generator Tests.* **A. F. McKissick.** (Amer. Instit. Elect. Engin. 15. pp. 457–473, 1898.)—An ordinary induction motor when driven mechanically above the speed of synchronism will act as a generator, and furnish energy to the polyphase alternator connected to it. A load of lamps may then be connected across the mains, and the induction motor will go on acting as a generator, so long as there is a synchronous motor (which may be kept running light) connected to it. Breaking the circuit or short-circuiting the mains immediately causes the "induction generator" to lose its E.M.F. The author gives a detailed account, with numerous curves, of some tests carried out with such an induction generator. The most probable use of the induction generator will be for boosting purposes. A. H.

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185. *Rotary Field Motors.* **S. Hanappe.** (Écl. Électr. 16. pp. 437–450, 1898.)—This is the beginning of a series of articles on the calculation and design of polyphase induction motors. W. G. R.

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186. *Regulation of Motors.* **R. E. Menges.** (Écl. Électr. 15. pp. 405–408, 1898.)—Some further remarks on motor starting and regulating switches. R. B. R.

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187. *Electric Railway Motors.* **G. T. Hanchett.** (Street Rly. Journ. 14. pp. 184–186 and 517–519.)—General data and dimensions are given; also descriptions of commutators and brush-holders. EDITOR.

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188. *Transformer for* 150,000 *volts.* **E. B. Paine** and **H. E. Gough.** (Elect. World, 32. pp. 63–65, 1898 ; also Journal of the Worcester Polytechnic Institute.)—A detailed account of the construction of a 20-kilowatt transformer, to transform from 50 or 100 volts to 150,000 volts at a frequency of 133. Kerosene oil was used as the insulator. The article contains some interesting photographic reproductions of discharges between terminals in air, under various conditions.

A. H.

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189. *Alternating Current Transformer.* **W. F. White.** (Amer. Instit. Elect. Engin. Trans. 15. pp. 389–398, 1898.)—The author shows how wasteful the system of distribution employing isolated transformers to every consumer may be. The author found in 1892, that one of the largest alternate current stations in the United States had an income of only 3d. per kilowatt hour output at the switchboard, although the consumers were charged 10d. per unit. In other words the transmission, transformation, and distribution losses are commonly as much as 200 per cent. of the consumer's demand as shown by the meters. This also means greatly increased cost of generation. An example is given of a plant which on January 1, 1895, supplied some 16,700 16 c.p. lamps using 547 transformers with an aggregate rated capacity of 22,190 lamps. The magnetising current of the system was about 80 amperes at 1,000 volts. A system of low tension distributing mains fed by large transformers was then introduced for the central parts of the town. As a result, although the lamps connected increased to 23,643, the total capacity of the transformers used has decreased to 14,946. The income per kilowatt hour at the switchboard has increased some 74 per cent. The author estimates that 1,857 tons of coal have been saved per annum by the change. In core losses alone the reduction at working charges have been enough to pay all costs for the change of lamps, meters, and transformers, and for the laying down of the secondary net work. In spite of the increase in the number of lamps connected, the magnetising current of the system has fallen from 80 to 30 amperes. The other advantages claimed are less cost of upkeep of transformers and a more regular pressure of supply.

R. W. W.

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190. *Transformer Economy.* **W. E. Goldsborough.** (Elect. World, 31. pp 781–784, 1898.)—Numerous tests in the Perdue laboratories on transformers of recent design have shown the money value per annum of deviations from the specified core loss, efficiency, &c. The cost of checking the performances of the transformers would often exceed the value

of the small margin in question. Non-aging transformer iron is a commercial possibility, but it is doubtful whether it can be obtained in sufficient quantities. The difficulty seems to be to get non-aging iron which will fulfil the usual specifications for core loss. Of six different types of transformers tested, the core loss increased from 5 to 10 per cent. in three months. The rate of increase in core loss diminishes with time. The author intends to carry out a series of aging tests for one year under continuous full load conditions. As regards oil insulation for transformers, a continued heating of the oil for a long time changes it to such an extent that on being cooled, its breakdown value is often reduced by four-fifths. To prevent this, the maximum temperature of the oil should never exceed 60 or 70° C. E. H. C.-H.

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191. *Improvements in Transformers.* **C. F. Guilbert.** (Écl. Électr. 16. pp. 230–236, 1898.)—This paper, which is mainly based on recent patent specifications, is of a purely descriptive nature, and deals with some recent improvements in the details of transformer construction. A. H.

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192. *Design of Phase Transformer.* **A. F. McKissick.** (Amer. Electn. 10. pp. 338–339, 1898.)—An account of the design and construction of a $2\frac{1}{2}$-kilowatt transformer, to be used for transforming 3-phase current at 220 volts to 2-phase current at 500 volts. A. H.

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193. *Current-rushes in Transformers.* **A. Hay.** (Elect. Rev. 43. pp. 326–327, and 333–336, 1898.)—When a transformer is switched on, the first few current-waves are in general of an abnormal type, each wave consisting of a large half-wave in one direction, followed by a small half-wave in the opposite direction. The initial counter E.M.F. waves are similarly distorted. Such abnormal waves settle down gradually to the normal type of wave. The phenomenon is capable of being explained in a comparatively simple manner by taking into account the known magnetic properties of iron. In no case is there any rise of potential difference across the transformer terminals, as has been sometimes asserted. The paper contains a number of curves (obtained experimentally) which fully bear out the above theoretical deductions. AUTHOR.

POWER DISTRIBUTION, TRACTION, AND LIGHTING.

194. *Long-distance Power Transmission.* **E. J. Berg.** (Elect. World, 32. p. 206, 1898.)—The author considers the problem from a general standpoint. He advocates single-phase in preference to multiphase systems, except when dealing with very long distances, or cases in which rotary converters are to be used. The question of frequency is also discussed in general terms. A. H.

195. *Pressure Regulation in Long-distance Transmission.* **E. J. Berg.** (Amer. Instit. Elect. Engin. 15. pp. 427–449, 1898.) (See also the previous Abstract.)—In the case of very long lines having considerable inductance, there is a serious difficulty in maintaining a constant pressure at the receiving end of the line by any system of control from the generating station. For the pressure required at the generating end will depend not only on the current and power-factor of the load, but also on whether the current is a lagging or leading one, the generator pressure being very different for the two cases. Where a rotary transformer system is used, the author recommends control at the receiving end by variations of the exciting current of the transformer. The theory of this mode of control is fully worked out. In order to render the control automatic, the field of the transformer should be compound-wound. This method of control, although very satisfactory when each converter is supplied by an independent generator, is not to be recommended when several converters are operated from the same generator, or from several generators in parallel, since in that case a change in the adjustment of the series field would have to be made with a change in the generator capacity. A. H.

196. *Transmission of Electrical Energy at Les Clées-Yverdon.* **J. Laffargue.** (Ind. Élect. 7. pp. 356–362, 1898.)—This is an account of the electric installation at Les Clées-Yverdon in Switzerland. At this place the river Orbe furnishes a good fall of water which is utilised. This fall which is 45 metres high drives turbines each of 300 horse-power at a speed of 430 revolutions per minute. To the shaft of each turbine an alternator is coupled by the Zodel flexible system. The alternators are tri-phase giving a pressure of 5,200 volts at a frequency of 50 alternations per second. From this station the neighbouring towns, to a distance of 15 to 20 miles, are supplied with light and power.

The charges for power for motive purposes varies from 240 to 150 francs per horse-power per year for large motors, and from 10 to 7·5 centimes per horse-power hour for small motors according to the size. W. G. R.

197. *Alternate Current Distribution.* **H. A. Wagner.** (Elect. World, 31. pp. 740–744, 1898.)—The author states that though many alternating current stations have been started, few in the United States have been a success. The fault lies, not with the alternating current, but with the method of its application. The regulation, which should be easier than in the case of direct currents is faulty, chiefly owing to the omission of taking potential wires from the centre of distribution to the central station. The direct current three-wire system is commended and should be applied to alternating currents. The regulation cannot be performed by supplementary bus bars, but the booster method can be used. In this way the high potential mains can be dispensed with and high potential limited to the feeders. By using this system the average load, and consequent efficiency, of the transformers is raised. W. G. R.

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198. *Direct and Alternating Current Distribution.* **L. A. Ferguson.** (Elect. World, 31. pp. 779–781, and 32. pp. 7–10, 1898.)—The author in this paper, read before the National Electric Light Association, June, 1898, describes the distribution system of the Chicago Edison Company, as representing the latest developments. The continuous three-wire network is supplied from four central stations whose maximum output in 1897 was 50,730 amperes at 215 volts. The average yearly efficiency of distribution was 91·2 per cent. from the station switchboards to the customer's meter. The largest station is connected to a substation in the centre of distribution in the business district by an immense trunk line, 3,340 feet long, having a total cross sectional area of 66,000,000 circular mils, which has carried a maximum of 34,400 amperes. Outlying districts are supplied from the large stations through rotary transformers which take direct current from the bus bars at 215 volts and convert it to three-phase alternating at 160 volts, which is raised by step-up transformers to 4,500 for transmission. At the receiving end, the volts are stepped-down to 80 and then converted into direct-current at 115 volts by means of rotary transformers. A pair of 200-kw. generators is being installed for this work, each being provided with three collector-rings and designed to deliver from the same armature direct-currents and three-phase alternating currents.

In the second part of his paper the author goes on to discuss arrangements for obtaining uniformity of pressure. For long feeders he recommends a series-wound booster, connected in series with the feeder and so designed that its voltage at constant speed will be proportional to the current passing through it. The standard system used by the Edison Companies throughout America consists of lengths of japanned iron pipe containing three solid copper wires or rods insulated from each other and from the iron pipe by an asphaltum compound. The tubes are 20 feet long, the conductors projecting 3 inches beyond the

ends. Tubes are connected at junction-boxes filled in with hot insulating compound. At each street-intersection is fixed a cylindrical junction-box containing three copper rings, to which the conductors are attached. This is the most complete and permanent system for direct-current distribution at 500 volts and under. Pressure charts illustrate the superiority in regulation of a direct over an alternating system. With the former, an average deviation of less than one volt should be obtained. To obtain first-class pressure-regulation with alternating distribution, the engineer must follow the lines laid down for the modern direct-current distribution system. As regards batteries, they are economically valuable in direct-current systems whose load curve has an average peak-width of not more than two hours, since the investment required for storage batteries to carry a peak of less width, is less than the investment required for steam and electrical machinery to do the same work. The superiority of direct-current for electric elevator work is emphasised and, as proof of the importance of this service, it is stated that the Edison Companies in New York, Boston, Brooklyn, and Chicago, supply for direct-connected elevators, 15,000 H.P. representing a gross income of 375,000 dollars annually. The author finds that the $3\frac{1}{2}$ amperes direct-current enclosed arc lamp successfully competes with the Welsbach gas-burner. In conclusion the opinion is expressed that the successful central station company of the future will be the one combining intelligently the use of alternating and direct currents, employing direct current for the distribution systems in the thickly settled business and residential districts, and alternating current for the distribution systems in the suburbs. The energy will be generated at one or two large condensing stations which will transmit low pressure direct-current, or high pressure alternating-current, according as the substations which they supply are relatively close at hand or far away.

E. H. C.-H.

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199. *Two-Wire Distribution.* **J. W. Howell.** (Amer. Instit. Elect. Engin. 15. pp. 373–378, 1898.)—The cheapness and simplicity of a two-wire system sometimes make it preferable to three wires. In distributor cables the section of the third wire should equal the outers. M. O'G.

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200. *Electrically Operated Auxiliary Plant at Bristol.* **H. F. Proctor.** (Elect. Rev. 43. pp. 404–406, 1898.)—In this paper, read before the British Association, the author gives a brief description of the Bristol electric lighting system and the detailed results of tests made to determine the comparative performance of steam and electricity in driving pumps, &c. The results are expressed in terms of steam used per B.H.P.

hour, on the basis of 32 lbs. steam per B.T.U., and are summarised below :—

	Steam.	Electricity.
Feed pumps.....	98 lbs.	43·2 lbs.
Donkey pumps	544 „	95·5 „
Circulating pumps	90·6 „	48·26 „
Centrifugal separators...	220 „	37·6 „

A. H. A.

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201. *Electrical Transmission of Energy.* **A. Siemens.** (Elect. Rev. 43. pp. 406–408, 1898.)—In this paper, read before the British Association, the author discusses the subject of electrical transmission in general, and describes the installation at the works of Siemens Bros. & Co., Charlton. The load factor during 1897 was 0·18; special tests in May and June, 1898, showed the day-load factor to be 0·36, with a consumption of 5·13 lbs. coal per B.T.U., while the night-load factor was 0·10, with 10·42 lbs. coal per B.T.U. The average coal consumption was 6·55 lbs. per B.T.U. The cost, inclusive of all charges, was 1·287d. per B.T.U. at the switchboard, and 2d. per B.T.U. given out by the motors. The expenses were divided as follows :—

Standing charges.....	49·1 per cent.
Fuel	26·8 „
Labour.....	12·0 „
Stores	6·0 „
Repairs	6·1 „

Particulars are also given of two installations for long-distance transmission on the three-phase system at 10,000 volts pressure.

A. H. A.

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202. *Electric Motive Power in Small Industries.* **A. H. Gibbings.** (Elect. Rev. 43. pp. 408–410, 1898.)—In this paper, read before the British Association, the author summarises the uses to which small electromotors may be applied, and discusses the reasons why they are not more generally adopted; he advocates the hiring-out of motors at a rental of about 10 per cent. upon their cost, and gives data showing the results of this system in two years' working at Bradford. A list of direct current central stations, with the number and H.P. of the motors supplied by them, is added. A. H. A.

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203. *Electric Light and Power on the Midland Railway.* **W. E. Langdon.** (Electrician, 41. pp. 754–757, 1898.)—A brief account is given of the electrical installations of the Midland Railway, with tables showing the cost of fuel and labour and

other particulars of the various generating stations. The average running cost in 1897 was 2·511d. per unit, inclusive of all repairs and renewals, but exclusive of interest and taxes. The Derby installation is treated more fully.

Experiments have been made to ascertain the power absorbed in driving shafting and small machine tools, of which the results are tabulated in detail; an extract from the tables is given below. The author concludes that a marked economy can be effected by driving direct with electromotors.

Power Absorbed in Driving Main Shaft, Counter Shafting, Belting, and Lathes. Main Shaft 98 ft. 4 in. long, 2 in. diameter, having Twelve Bearings each $4\frac{3}{8}$ in. long, and ordinarily driving nineteen Belts.

Machine.	Work done, metal cut away.					Power absorbed.					
Description.	Weight.		Traverse.	Time occupied.	Total revs. of metal cut per min.	Main shaft.	Counter shafting.	Machine.	Cut.	Total.	Per oz. metal cut per min.
	Total cut	Cut per minute.									
	oz.	oz.	in.	m. s.	revs.	watts	watts	watts	watts	watts	watts
9½ in. screw-cutting lathe	2½	1·1	3⅜	2 20	250	272	55	54	164	545	509
6 in. lathe	2¼	1·1	3	2 0	394	272	82	55	245	654	584
5 in. lathe	2¼	1·0	3	2 20	393	272	55	82	136	545	567
6 in. saw	1¼	0·5	..	2 30	1,827	272	55	27	136	490	980
¼ in drill	¼	0·08	..	3 0	310	272	82	..	27	381	4,950
Grindstone	..	..	..	2 30	100	272	..	82	191	545	..
Buff	..	..	..	2 30	1,300	272	55	27	82	436	..
10 in. screw-cutting lathe	2¾	1·0	3	2 20	190	272	137	27	54	490	507
1 to 2 in. drill	4½	1·7	..	2 30	156	272	88	76	272	708	416
6 in. screw-cutting lathe	2	1·7	3	1 10	272	272	55	27	191	545	317
6 in. lathe	2⅝	2·4	3	1 10	380	272	109	55	109	545	230
6 in. lathe	2	2·4	3	0 50	362	272	137	27	163	599	246
5½ in. screw-cutting lathe	2½	1·0	3	2 30	300	272	82	17	65	436	436
5 in. lathe	2½	1·0	3	2 25	362	272	82	55	136	545	524
¼ to 1½ in. drill	¼	0·1	..	2 15	220	272	88	76	54	490	4,454

A. H. A.

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204. *Central Station at St. Louis.* **G. A. Damon.** (Elect. World, 32. pp. 36–38, 1898.)—This is a description of the plant of the Imperial Electric Light, Heat and Power Company, of St. Louis, Mo. A point of special interest is the method of connecting generators to prime movers. The engines are directly connected to four 500-kilowatt generators and two 50-kilowatt boosters by means of the "Arnold System." The idea of the system is to improve upon the usual direct connected unit principle by mounting each generator in such a manner that it

can be operated by more than one engine. Three engines are to be used on one shaft, the capacity of the centre engine being 1,500 horse-power, and double that of either end engine. The central engine has a sufficient capacity to operate two of the generators, while either end engine can drive one generator.

Each generator armature is mounted on a hollow shaft or quill, which is carried on independent bearings. The booster armature is attached to the solid shaft. This shaft is made of forged steel and is extended at both ends through the hollow generator-quills, but without touching them, so that it is supported in its own bearings between the two quills. By means of this shaft any engine can reach the generators not contiguous to it, but under all normal operating conditions this shaft does not turn, so that this system of connecting involves no more friction and requires no more lubrication than the ordinary arrangement. The coupling on the end of the shaft permits of three combinations: The engine may be directly connected with the quill of the adjacent generator, allowing the interior shaft to remain idle, or the solid shaft may be attached to either the engine flange or to the generator-quill. The clutch is of the magnetic type.

W. G. R.

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205. *Missouri-Edison Electric Company of St. Louis.* **H. A. Wagner.** (Elect. Engin. N.Y. 25. pp. 629–648, 1898.)—This is a very complete and illustrated description of the works of the Electric Company of St. Louis. It is useful in giving the details of the management and arrangement of high tension alternating current machinery on a large scale, the aggregate horse-power being 11,000. W. G. R.

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206. *Cork Electric Tramways.* **B. Griffin.** (Elect. Engin. 22. pp. 200–203, 1898.)—There are 11 miles of track, mostly single line, of which $1\frac{3}{4}$ miles, being beyond the city, are laid with sleepers. The steepest grade is 1 in 14, and the sharpest curve is 27 ft. radius. American $6\frac{1}{2}$ in. girder rails are used, 83 lbs. to the yard. The plant comprises three McIntosh & Seymour compound condensing engines direct coupled to 220-kw. generators, running 150 revolutions per minute; three Babcock and Wilcox boilers evaporating 8,000 lbs. of water per hour; also 256 tudor cells, capable of discharging 110 amperes for 7 hours. The chimney, which is 130 ft. high and 7 ft. 6 in. in diameter, is built of riveted steel plates, 4 ft. 6 in. high, 7/16 in. thick at bottom, and $\frac{1}{4}$ in. thick at top. It is claimed that the saving in cost of the steel shaft over a brick stack was about 25 per cent., while the time in erection was reduced.

E. H. C.-H.

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207. *Electric Traction on the Erie Railroad.* (Elect. World, 32. pp. 256–257, 1898.)—The branch of this railroad running from Tonawanda to Lockport, N.Y., and formerly operated by steam locomotives, has recently been provided with electric equipment. Passenger traffic is carried on trolley cars and freight service by electric locomotives. The cars also run over various electric railway systems in the neighbourhood. Power is obtained from the Niagara Falls Power Company at 10,500 volts, carried in 4/0 bare copper wires on cedar poles to a rotary-converter sub-station. Special high-tension switches are used, the blades of which are pulled down by means of a hooked stick. Two 36-ton locomotives are used, each equipped with a K 24 controller and 4 G.E.-55 motors, each rated at 160 H.P. The draw-bar pull at full speed is 3,400 lbs., handling a 340 ton train at 15 miles per hr. The trolleys of the locomotives are pneumatically controlled. The passenger cars are each equipped with B-8 controllers and 4 G.E.-57 motors, each rated at 52 H.P., with electric brakes on each axle, calculated to give a service at an average speed of 45 to 50 miles per hr. E. H. C.-H.

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208. *Electric Railways of Springfield and Holyoke, Mass.* (Street Rly. Journ. 14. pp. 415–423, 1898.)—The power station for the Springfield system contains two 1,200 H.P. cross-compound Hamilton-Corliss engines, and one 600 H.P. tandem-compound McIntosh & Seymour engine, each of the former being direct connected to an 800-kw. G.E. generator, and the latter belted to two 200-kw. Westinghouse generators. The Holyoke plant comprises three Green engines connected to 300-kw. G.E. generators. No chimney-stack is employed, but mechanical draught is provided by a duplicate set of 8 ft. fans. The Mount Tom mountain-line, which rises 700 ft. in 4,900 ft., with a maximum grade of $21\frac{1}{2}$ per cent., is worked by two cars connected by a $1\frac{1}{4}$ in. cable over an 8 ft. return sheave at the upper end of the line. There are no winding engines to drive the cable, but each car is equipped with two G.E. 1,000 motors, the cable being used only to balance the dead weight in the cars. E. H. C.-H.

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209. *The Boston Subway.* (Street Rly. Journ. 14. pp. 493–500, 1898.)—In December, 1894, the Boston Transit Commissioners found that 79,944 passengers got off and 96,590 passengers got on cars on the route to the proposed subway, and at one point 215 north-bound cars and 191 south-bound cars passed in one hour. The subway was accordingly designed to accommodate with ease this amount of traffic. Plans, sections, and illustrations of the subway and stations are given with particulars of method and cost of construction. To avoid stopping traffic, most of the

subway was built in slices, the ordinary street traffic being bridged over the trench thus formed. The right to use the subway has been leased by the city for 20 years to the West End Street Railway Co. for an annual payment equal to 4 $\frac{7}{8}$ per cent. of the net cost of the subway. E. H. C.-H.

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210. *Electric Traction at Havre.* (Écl. Électr. 14. pp. 564–566, 1898.)—The tramway connecting the town of Havre with the Sainte-Marie Hill commenced working last September, and although only 750 metres long, offered special difficulties owing to the narrowness of the streets and to the steep gradients, this being one of the steepest lines in Europe. It was carried out by the Thomson-Houston Co., who supplied special cars, each carrying two G.E. 1,200-motors, capable together of developing 100 H.P.

Three special brakes are employed, any of which are alone sufficient to stop the car. They consist of: (1) a magnetic brake; (2) a brake consisting of four friction-blocks operated by an endless screw; (3) a brake consisting of sliding shoes also worked by an endless screw and powerful enough to raise the car on to the shoes. Besides these, two devices are employed, operated from either end of the car, to avoid any chance of running downhill in the event of the current being broken. The cars are fitted with sandboxes in order to prevent skidding in coming downhill. The cars ascend and descend at the rates of 12 and 8·5 km. per hour respectively. The current supplied to the motors varies from 90 to 140 amperes, according to the gradient. L. J. S.

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211. *Three-phase Tramway at Evian-les-Bains.* (Electrician, 41. p. 580, 1898.)—Current is transmitted at 5,200 volts at a frequency of 50 from an old three-phase station eight miles away, and is converted by a 30-kw. stationary transformer to 200 volts. This transformer feeds a 6-H.P. motor for an hotel lift as well as the trolley line. The one car on the line is fitted with one three-phase motor rated at 15 H.P. but capable of 30 H.P. for a short time. The motor, whose speed is 750 R.P.M., drives a countershaft through spur gearing; the countershaft being connected to the axles by chain gearing. This arrangement is claimed to give sufficient adhesion for the heavy gradients on the line, the worst of which is 10·2 per cent. The motor is in circuit during ascent and descent, in the latter case running as a generator slightly faster than the speed of synchronism. If one of the trollies gets off the wire the motor continues to run as a single-phase motor. The car weighs 3·8 tons, holds 14 passengers, and makes 60 double journeys a day at a speed of 6$\frac{1}{4}$ miles per hour. E. H. C.-H.

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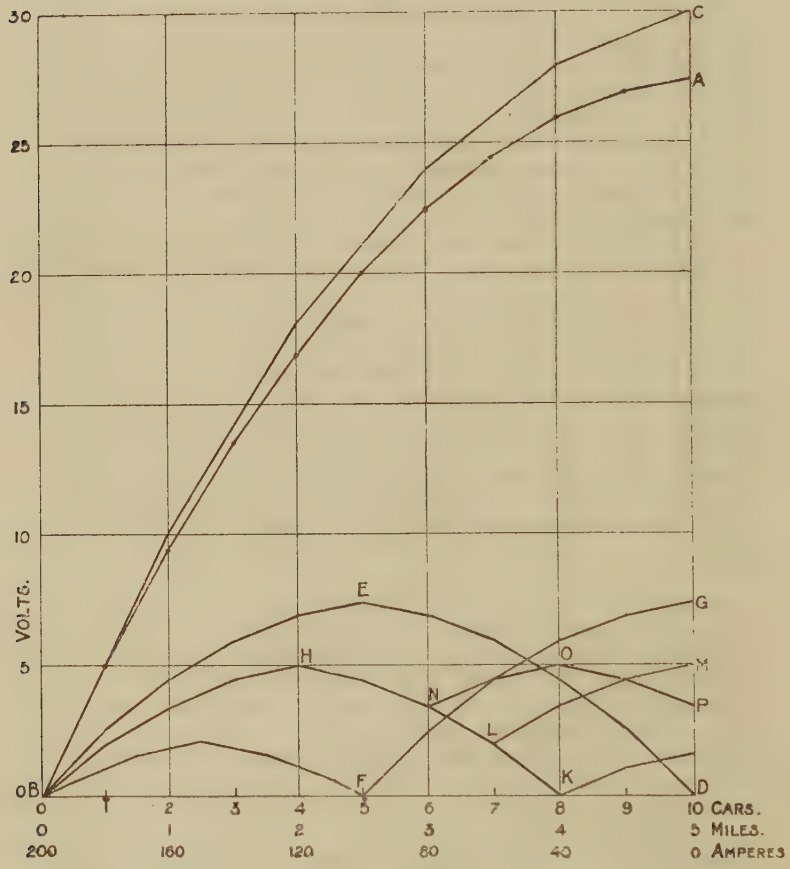
212. *Electric Tramways.* **P. Cardew** and **A. P. Trotter.** (Instit. Elect. Engin. Journ. 135. pp. 456–460, 1898.)—"A neat graphical method of determining the fall of potential in the return with uniform distribution of current, and the proper points of application of return feeders," is given in the form of a note by A. P. Trotter. Assume 10 cars each taking 20 amps., on a line 5 miles long, with turn outs, the resistance of the bonded rails



being 1/20 ohm per mile. Then when the cars are evenly distributed, the series is as follows :—

Cars	1	2	3	4	5	6	7	8	9	10 Works.
Volts	0	½	1½	3	5	7½	10½	14	18	22½ 27½.

The line A B shows the fall of volts in this case, and the line C B when the cars are in pairs a mile apart. The difference in drop in the two cases is negligible.

To reduce this fall of volts, the rails may be tapped by a return feeder connected with a negative booster which "sucks the current back," and thus the rails at the feeder end may be brought to zero potential or less. The problem is (*a*) to reduce the volts below a fixed maximum; (*b*) to use as little copper as possible; and (*c*) to use as little energy as possible. Disregarding the last two conditions, the volts at the far end of the line might be brought to zero by a single feeder to that point. To draw the curve of distribution, cut out a piece of card to the shape of the curve of volts A B, and fitting the vertical axis to the ordinate 5, place it so that it passes through the point D. Turn the card over, and complete the curve through B in the same way. The maximum volts, at the point E, are $7\frac{1}{2}$. Similarly, we can by the template draw B F G showing distribution with one feeder to the middle point of the line. Again, given the drop allowable, we can draw B H K by the template. But it is not necessary to reduce the drop so much on the last part of line, and we therefore find, by use of the template, that if we let the drop rise to the maximum at the end of the line, the feeder must tap at L. This is the best arrangement possible with a single return feeder.

A "Note on Electric Tramways," prepared by P. Cardew in 1894, is then given. If we assume n auxiliary conductors, all of equal resistance, connected to the main conductor at equal distances throughout its length, and one from the extreme end of the main conductor of twice the resistance of the others, a resistance equal to this last being interposed between the generator and the near end of the main conductor, then with a uniform distribution of current all the points of junction will be at the same potential, and the extreme difference of potential between any points of the main conductor will be reduced to $\frac{1}{4(n+1)^2}$ of what it would be without these auxiliary conductors or feeders. Instead of adjusting the resistances of all feeders to equality, varying E.M.F.'s may be introduced into each feeder, proportionate to its resistance.

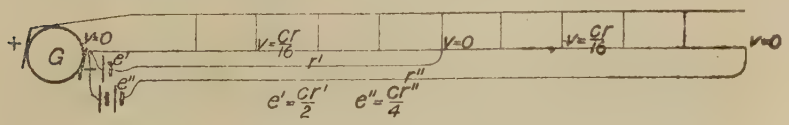


FIG. 4.

NOTE.—V indicates potential with regard to earth; e' and e'' auxiliary E.M.F.'s.

The disposition shown in Fig. 4 would be defective at times unless the E.M.F.'s were continually adjusted to the variations of load. Automatic adjustment may be obtained by the following arrangement: Divide the tramway into several sections according to its length, and the amount of traffic, gradients, &c.

Provide for each section two insulated feeders, one for the line and one for the return. Let the currents in these feeders pass through a motor generator at the generating station, the field magnets of which are excited by the current to line alone, while the armature is wound with two circuits—one for each current, so as to oppose each other—the circuit through which the current to line passes being made slightly the more powerful. The motor generator will then revolve as urged by the line current, and will generate an auxiliary E.M.F. for the return current.

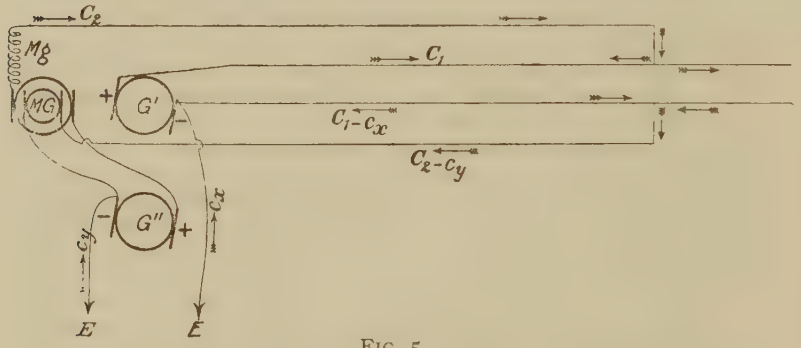


FIG. 5.

G' = generator ; G'' = auxiliary generator ; MG = motor generator ; Mg = magnetising coils of motor generator.

This system may be expensive, but can be adapted to lessen the drop at any part of an existing tramway. Such an arrangement with one pair of feeders is sketched in Fig. 5.

E. H. C.-H.

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213. *Electric Traction.* **P. Lauriol.** (Écl. Électr. 16. pp. 192–202, and 203–208, 1898.)—Notes on electric traction in about 30 European towns. EDITOR.

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214. *Cost of Electric Tramways. Street Railway Results.* (Street Rly. Journ. 14. pp. 471–492, 1898.) This paper contains an account of the capital outlay, traffic, and operating expenses of 39 street railways in Boston City and 75 suburbs. After illustrating and describing the various systems, the paper concludes with a *résumé* of investments and operating statistics for the nine groups into which it divides the systems. Emphasis is laid on the fact, that owing to the unusual care of the Railroad Commissioners in Massachusetts, these figures are among the truest available measures of value of both construction, costs, and earning power which can be found for street railways in America.

E. H. C.-H.

215. *Jenny Conduit System.* (Street Rly. Journ. 14. p. 563, 1898.)—This system, for which small first cost, thorough insulation, and simplicity are claimed, was invented some years ago, but has only recently been put into use. The conductor is a flat-headed rail, supported from the fish-plates by upwardly inclined arms with bell-shape ends, which fit over petticoated insulators. Contact is made by a brush supported by a bar passing through the slot, and held down by its own weight. Construction at crossings is claimed to be especially simple.

E. H. C.-H.

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216. *Moreau Closed Conduit System.* (Électricien, 15. pp. 296–297, 1898.)—The Moreau distributor consists of a device in which the motion of the front wheel of the car causes a rotating contact maker to advance by one tooth by the action of a pawl, this connects the rail or contact under the car to the feeder. The second wheel causes the contact maker to advance by another tooth, and the local circuit is then broken. This process is repeated on the passage of the next car. This system, which is very strongly constructed, appears to be capable of reliable working. The author criticises the large number of distributing boxes which the system requires. To avoid the large number of sections on curves of small radius it would be necessary to use bogie cars. This remark would apply to all systems belonging to this class.

L. J. S.

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217. *Thompson-Walker Surface Contact System.* **S. P. Thompson** and **M. Walker.** (Electrician, 41. pp. 751–754, 1898.)—The authors give an outline description of the more important surface contact systems which have been brought forward since 1881, and point out that, while those which depend upon the action of a magnet carried on the car are, in general, free from risk of operation at the wrong time, they are not so positive in action as those in which the electromagnet is combined with the switch.

The authors propose to combine the advantages of both methods, without the defects of either, by using an electromagnetic switch actuated by a mass of iron on the car. The electromagnet consists of an iron core sliding vertically in a solenoid, with expanded iron heads so shaped that the core has no tendency to rise when a current is flowing in the solenoid, unless there is a mass of iron immediately above the contact stud. The apparatus is placed in a cast-iron box filled with oil; when the iron core rises, the displacement of the oil permits a float to fall and close a mercury switch, making the contact stud "alive." When the skate which is carried on the car breaks contact with the stud, the iron core falls, raising the float and opening the mercury switch; at the same time a mercury contact is made,

by which the stud is earthed, so that if by any chance the switch should remain closed, a fuse would be blown and the apparatus cut out of action. The paper is illustrated with figures and diagrams of connections. A. H. A.

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218. *Corrosion of Pipes by Return Currents of Electric Tramways.* **J. A. Fleming.** (Electrician, 41. pp. 689–692, 1898.)—The author discusses the Board of Trade Regulation No. 6 (ii.), which limits the potential difference between the rails and buried pipes, and describes experiments made to determine whether corrosive action can occur when this regulation is obeyed. The specific resistance of moist clay was found to be about 1,566 ohms ; this greatly increased as the moisture evaporated, showing that the conduction was in great part electrolytic. Tests made on a small scale showed that electrolytic corrosion took place with a potential difference of one volt or less, iron being removed at a far greater rate than corresponded with theory ; these experiments were repeated on a practical scale over a period of six months, with similar results. In the case of an electric tramway, part of the return current must leave the rail at points of high potential and flow through the earth, &c., to points of lower potential ; the effect of this on pipes depends on their position with regard to the lines of current flow. A model was made to represent an actual tramway system, with pipes running in various directions, by means of which a survey could be made of the electrical conditions set up, and information gained as to the probable locality of corrosive effects. The author concludes with a summary of the facts bearing on the subject, and the conditions under which corrosion may be expected to take place.

A. H. A.

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219. *Earth Returns, and Electrolysis.* **A. B. Herrick.** (Eng. Mag. pp. 451–457, 1898.)—The action of the ground-current on various kinds of pipes is discussed, and remedies are suggested. Cast-iron pipes are not attacked so rapidly as wrought-iron ; lead surfaces and brass nipples suffer most. Clay is the best soil for insulating purposes ; loam charged with salt water the worst. If saturated with coal- or sewer-gas, the resistance of the soil is greatly reduced. Current leaving the rail increases the capillary activity of the soil, and draws water towards the rail. The rail positive to the soil is always moist. E. H. C.-H.

TELEGRAPHY AND TELEPHONY.

220. *Hertz Telegraphy.* **M. Tietz.** (Electrician, 41, pp. 658–660, 1898, and Elektrotechn. Zeitschr. Aug. 18, 1898.)—Quantitative experiments are described, using a Klemenčič thermo-element or a Ruben's bolometer, to determine the intensity of received waves. When the radiator is a point, the inverse-square law holds; when it is a line, the intensity varies directly as the distance. Hence the advantage of adding a wire to the sending and receiving apparatus. Curves are drawn indicating that intensity, in practice, varies according to a law intermediate to these two cases. Results obtained with different detectors (spark-gap, coherer, bolometer) are not always in agreement. The quantitative change of resistance of a coherer does not appear to bear any definite relation to the constants of the emitter, and it seems to be independent of the length of the "collecting wire." Syntony is therefore necessarily imperfect so long as a coherer is used as the receiver. The thermo-element and the dynamo-bolometer have greater possibilities than the coherer as regards syntony.

The author recommends a radiator formed by putting short, bent pieces of wire into a block of paraffin wax, with a short spark-gap between each pair of wires. The whole is immersed in oil in an ebonite box. This radiator is said to be 20 times more effective than the Marconi-Righi apparatus. As a receiver, the bolometer was more sensitive than the thermo-element in the ratio of 13 to 5. A receiver is suggested consisting of thermo-elements of alternate large and small junctions. The remainder of the original article is devoted to the proposition to use a selenium cell as a sensitive relay. (With regard to the history of the "collecting" wire, reference should be made to the Electrician, 39. p. 832, 1897. For experiments on the selenium cell as a relay, see Proceed. Physical Soc. vol. ii. pp. 96–98, 1891.) R. A.

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221. *Syntonised Vibrators for Wireless Telegraphy.* (Elect. Rev. 43. pp. 260–263, 1898.)—This is a description of improvements devised by Lodge in apparatus for "sending" and "receiving"; they are the outcome of examining the theoretical conditions of syntony. Diagrams are given of "discharge gaps" associated with capacity areas and self-inductance coils, designed to prolong the series of electric oscillations in the radiator, and to give them definite pitch. The connections are in most of these cases arranged so that the charges of electricity, after being communicated to the radiator system, oscillate free from the disturbances of supply wires. Methods are also described for charging the capacity areas with an "impulsive rush." The

capacity areas may take the form of a roof of a shed or other building, which may be used to contain the other instruments. Particulars are given of the self-inductive coils, and the switches to be used for adjusting the conditions of syntony. This article appears to have been developed from Patent Specifications, but references are omitted. (See Proceed. Physical Soc. vol. xvi. pt. 1. pp. 58–61, 1898.) R. A.

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222. *Wireless Telegraphy.* **Schluckebier.** (Archiv Post Tele. 7. pp. 208–214 and 240–246, 1898.)—An interesting *résumé* of the history of the subject, both as regards the utilisation of earth-currents and the Marconi methods. The experiments of the British and German Post Offices and of the Italian Marine are described, as well as those of Prof. Slàby, and the application of Marconi telegraphy to Hughes' instruments by Dr. Strecker, and Slàby's observation that Marconi's method, applied parallel to the ordinary telegraph wire, enables an independent set of messages to be sent along with the ordinary telegraph signals to distances much greater than those for which wireless telegraphy is practicable across free space. A. D.

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223. *New Telephone System in Paris.* **M. O'Gorman.** (Lightning, 14. pp. 196–197, 1898.)—The multiple boards are with jacks in parallel without test keys and with indicators automatically reset. When a jack is plugged, the corresponding call-index disappears and is insulated from the speaking line. A new departure is made by the use of a visible indicator on each outgoing jack repeated on every operators section as long as that jack is in use; it automatically disappears when that line is free. This saves much time. AUTHOR.

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224. *Telephone Systems.* **C. Raphael.** (Electrician, 41. pp. 85–88, and 494–498, 1898.)—Descriptive of the systems in Great Britain. EDITOR.

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225. *Telephone Work.* **A. E. Dobbs.** (Elect. Engin. N.Y. 25. pp. 605–607, 657–658, 679–680, 711–712, and 26. pp. 12–13, 31–32, 108–110, and 127–128, 1898.)—Practical notes. EDITOR.

SCIENCE ABSTRACTS.

PHYSICS AND ELECTRICAL ENGINEERING.

FEBRUARY 1899.

GENERAL PHYSICS.

226. *Deformation of Metals affected by Time.* **G. Charpy.** (Paris, Soc. Franc. Phys. Bull. 114. pp. 1–2, 1898.)—The deformation produced by a force acting on a fragment of metal depends on the time during which this force acts. This phenomenon is more or less marked according to the nature of the metal; very marked with lead, it is almost inappreciable in the case of red copper under ordinary conditions of experiment. The author studies this latter case, which is particularly interesting since the crushing of copper cylinders is utilised for measuring the explosive pressures in closed spaces. Experiments effected by means of an apparatus allowing the time of crushing to vary from several minutes to 1/10 of a second prove that the deformation produced by a given charge is smaller as the duration of the time of action is shorter. It follows that the explosive pressures measured by these means with the tables actually employed are too small, and ought to be multiplied by a coefficient of value between 1·1 and 1·2. E. C. R.

227. *Surface Tension of Water.* **P. Volkmann.** (Wied. Annalen, 66. 2. pp. 194–206, 1898.)—Measurements of the surface tension of water in freshly drawn capillary tubes show a satisfactory agreement among themselves, which is independent of the substance and of the width of the tube. This agreement is not lost after two months, provided the tubes are kept under water, thus preserving the mobility of the liquid column. These results are opposed to those of Quincke, who found a considerable variation of the surface tension with width and substance of tube, even in freshly drawn tubes. The author attributes the

difference to a probable error due to Quincke's method of determining the width of the tubes. He finds that in old tubes cleaned with caustic potash and water the surface tension is less by 0·02 mg/mm. This he attributes to a higher solubility of newly drawn glass, thus indirectly conceding the influence of the substance of the tube. E. E. F.

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228. *Surface Tension of Mercury.* **J. Stöckle.** (Wied. Annalen, 66. 3. pp. 499–522, 1898.)—According to Quincke, the values of the surface tension of mercury found by different physicists vary between 44 and 56 mg/mm. The author seeks the cause of the discrepancy in the condensation of gases in the mercury surface. He eliminated it by observing the scale divisions of a glass scale as reflected in a drop of mercury in a vacuum. The drop projected from the end of a vertical tube introduced from below into a vacuum by means of an air-tight joint. He found that the surface tension of mercury in a vacuum only filled with residual mercury vapour is constant, and amounts to 44·4 mg/mm. In gases, the surface tension is greater when the surface is fresh, but the excess disappears after a while, rapidly in hydrogen, and slowly in nitrogen. It is due to a condensation of the gas on the surface, which is known to be most active in the case of hydrogen. E. E. F.

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229. *Surface Tension of Mercury.* **G. Meyer.** (Wied. Annalen, 66. 3. pp. 523–529, 1898.)—The condensation of a gas on the surface of mercury may be almost entirely eliminated in surface-tension measurements by measuring the waves on a jet of mercury. This may be described as the dynamic method. The values obtained are always larger than those obtained by the static method, evidently because the decrease of surface tension brought about by condensation has no time to set in. The values obtained are, for air 51·5, oxygen 51·4, nitrogen 50·5, carbonic acid 49·6, and hydrogen 56·5. E. E. F.

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230. *Physical Properties of Caoutchouc.* **A. E. Lundal.** (Wied. Annalen, 66. 4. pp. 741–759, 1898.)—Among the peculiarities studied are the absorption of paraffin oil and its attendant changes of density, the expansion, elasticity, and compressibility of caoutchouc, and certain thermodynamic phenomena connected with it, such as the loss of heat on sudden stretching. E. E. F.

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231. *Newton's Third Law of Motion.* **P. Volkmann.** (Wied. Annalen, 66. 4. pp. 781–784, 1898.)—The author points out, in correction of the prevailing assumption, that Newton's laws of motion do not deal with or lead up to the idea of central forces. The conception of the latter is based upon his law of gravitation, which in his system was one of the final conclusions arrived at.

E. E. F.

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232. *Gravitational Constant.* **F. Richarz** and **O. Krigar-Menzel.** (Wied. Annalen, 66. 2. pp. 177–193, 1898.)—The constant of gravitational attraction was determined by means of a double balance, provided, in addition to the ordinary scales, with another pair of scales attached to the upper pair by means of rods 226 cm. long. Two kilogramme weights were placed on the upper right- and the lower left-hand scale respectively, and the difference of weight due to the difference of altitude was determined. Then a mass of lead 100,000 kgr. in weight was introduced between the upper and lower scales, and the weight of a kilogramme above and below the mass was determined. The result gave the attraction of the mass, free from errors due to difference of altitude. The value for the gravitational constant obtained was $(6{\cdot}685 \pm 0{\cdot}011) \times 10^{-8}$ cm.^{3}/gr. sec.^{2}, and the value for the earth's mean density was $5{\cdot}505 \pm 0{\cdot}009$. E. E. F.

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233. *Stellar Velocities.* **W. W. Campbell.** (Ast. Phys. Journ. 8. pp. 123–159, 1898.)—As illustrative of a paper on the new "Mills Spectrograph" recently acquired by the Lick Observatory, the author gives tables showing the results of his observations on the velocity of stars in the line of sight. In all he discusses twelve stars, and a valuable addition is the comparison he gives with previous observations by Vogel and Scheiner.

Another very valuable adjunct is the bringing together of the formulæ and data required for computing the velocity of a planet at any instant with respect to the earth or the sun. These are requisite before any estimate can be made of a star's velocity, and reference to the table in the paper will facilitate their determination. Attention is drawn (p. 157) to the exceedingly large velocities of the three stars η Cephei, ζ Herculis, and G. C. 4373, all having a velocity greater than 50 kilometres per second.

C. P. B.

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234. *Nickel and its Alloys.* **C. E. Guillaume.** (Écl. Électr. 16. pp. 287–292, 1898.)—This contains a summary of the results obtained by the author in his researches on nickel and nickel-steels, of which he has published an account in a small pamphlet. The principal points are referred to in Abstract

No. 1115 (1898.) The author considers that some of the peculiarities noticed may be due to a variation of the affinity of iron and nickel according to temperature. Various practical uses for the alloys are suggested, such as in instruments where a small coefficient of expansion is desired in the material, or where this expansion should be the same as that of glass. Another use might be the complete compensation of pendulums for temperature, and not merely for two temperatures. J. J. S.

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235. *Macrae Curve-Tracer and Integrator.* (West. Electn. 23. p. 52, 1898.)—In this instrument a number of pencils are arranged to act on a continuous band of section paper so as to mark at suitable distances apart. These pencils are each mounted on a sliding rack-bar, adapted to be moved by a pinion on a shaft provided with a handle and with a pointer moving over a graduated scale; a ratchet-feed is also provided for moving the continuous band forward through a predetermined distance by actuating a lever. Each dial is graduated according to the quantity to be indicated in the corresponding curve, for example, volts, amperes, steam-pressure in lbs. per sq. in. When a set of readings is to be taken and recorded, the pointers are set to the observed values and the paper-band then moved forward through unit distance so as to mark part of a stepped curve.

To measure ampere-hours, or other quantities involving integration, the dial is provided with two pointers, one of which is fixed on the shaft and marks the position of the pencil which traces the curve. The other pointer is connected to the fixed pointer by a clutch in such a manner that when the fixed pointer is moved forward it brings the auxiliary pointer along with it, but when the fixed pointer is moved back, the auxiliary pointer remains stationary. Each time the fixed pointer is to be set for a reading, it is first moved back to zero and then brought to the position in which it is to remain until the next reading is taken. The auxiliary pointer thus integrates the curve recorded. C. K. F.

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236. *Relief-Pictures for the Blind.* — **Dussaud.** (Comptes Rendus, 127. pp. 417–418, 1898.)—This is a hypothetical arrangement of perforated screens and selenium cells for producing relief-models of a luminous picture. Each cell actuates a telephone, the diaphragm of which communicates motion to a rod, thrusting it forward or causing it to recede. The ends of all the rods map out a surface which at any instant depends upon the illumination of the distributed cells. It is proposed by this means to convey to the blind some idea of the form of the luminous picture. R. A.

LIGHT.

237. *Illustrations of Optical Phenomena.* **J. D. Everett.** (Phil. Mag. 46. pp. 227–243, 1898.)—Analogies drawn from chains of particles and from mutually influencing pendulums are used to illustrate certain optical phenomena. The methods of establishing the most important properties are selected so as to be brief and simple, and the author has arranged both proofs and results in a form convenient for reference. The properties of the double pendulum are discussed very fully. The usual investigation with regard to mutually influencing pendulums is simplified by first assuming the motion to take place in a fundamental mode, and afterwards discussing combinations of such modes. The discussion of the simple harmonic vibrations of a chain of particles is applied to explain Stokes's illustration of fluorescence. Lord Rayleigh's application of the case of the pendulums to explain anomalous dispersion is referred to; and also Sellmeier's theory of fluorescence. J. J. S.

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238. *Newton's Rings.* **T. C. Porter.** (Phil. Mag. 46. pp. 245–252, 1898.)—A description is given of a new method of viewing Newton's rings by the light emitted from the two interior surfaces of two glass plates placed close together, free from all other light except only that due to reflections in the air-space. The subordinate interference systems which coexist with the primary rings are for the first time shown to the eye, and these can be analysed experimentally. The results obtained indicate that most probably the interference of monochromatic light in forming the rings is never absolutely complete, though very nearly so. J. J. S.

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239. *Colour-Vision.* **F. P. Whitman.** (Science, 8. pp. 305–316, 1898.)—An interesting historical summary of the various theories which have been put forward to account for colour-vision. J. J. S.

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240. *Colour Measurement.* **T. E. Doubt.** (Phil. Mag. 46. pp. 216–222, 1898.)—After discussing the standards used by Maxwell, Rayleigh, and Helmholtz, the author proceeds to describe an instrument designed to compare the mixture of two or more components of a single light source with the original light source itself. The instrument consists of a spectroscope used after Foucault's plan for colour mixtures, but employing a concave silver-on-glass mirror instead of a lens to collect the

isolated components of the analysed light. By sending the beam through the prism system twice, the instrument is made very compact, and the method of comparison by using a diagonal silvered mirror between the slit and collimating lens allows of the original light being seen in juxtaposition with the colour or mixture of colours with which it has to be compared. The paper gives the colour equations for white light obtained by using three different sources of comparison—an Argand burner, an amyl acetate lamp, and a Carcel lamp. C. P. B.

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241. *Measurement of Illumination.* **Onimus.** (Comptes Rendus, 127. pp. 663–664, 1898.)—This apparatus for measuring the total intensity of daylight consists of a box in the lid of which are 24 holes hearing the numbers 1 to 24. Hole No. 1 is covered by a film of collodion slightly tinted with Aurentia, hole No. 2 with two films superposed, and so on. Sensitive paper (preferably ferro-prussiate) is exposed under the holes, and the highest number marked on the paper is a relative measurement of the intensity. E. C. R.

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242. *Theory of Welsbach Incandescent Mantle.* **Bunte.** (Paris Soc. Franc. Phys. Bull. 114. p. 2, 1898.)—Nearly all mantles in use have practically the same composition—88 to 89 per cent. oxide of thorium, 20 per cent. oxide of cerium, and traces of other matter which only play a quite secondary part. The lighting power of mantles is not due to any special emissive power, as is proved by observing the emissivity of oxides of thorium, cerium, and magnesium, and of retort carbon heated in an electric furnace to a temperature of about 2,000°. The lighting power results simply from the high temperature to which the mantle is raised, and which is due (1) to the catalytic properties of oxide of cerium and (2) to the fine sub-division of the latter. The presence of oxide of cerium lowers the temperature of combustion of a mixture of oxygen and hydrogen from 650° to 350°; the combustion is consequently strongly active in the neighbourhood of the mantle, and a large quantity of heat is disengaged. The oxide of thorium forms a porous mass consisting of a large number of very fine filaments, which are coated with oxide of cerium. On account of the bad conductivity of these fine filaments, the heat, instead of being rapidly dissipated in the mass, is concentrated on the filaments, and the mantle is raised to a very high temperature. It is certain that the two oxides are both necessary to obtain a good result, for mantles of pure oxides of thorium or cerium give ten to twenty times less light.

E. C. R.

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243. *Prismatic Images.* **R. Straubel.** (Wied. Annalen, 66. 2. pp. 346–349, 1898.)—The author shows that when a plane surface is viewed through a prism, the orientation of the image is different from that of the object, and that this orientation is independent of the distance of the object. In Abbé's dilatometer, for instance, a focal difference of 3·76 cm. corresponds to an extension of the object normally to the refracting edge by 1 cm.

E. E. F.

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244. *Distribution of Light on the Focal Plane of a Photographic Objective.* **M. von Rohr.** (Zeitschr. Instrumentenk. 18. pp. 171–180 and 197–205, 1898.)—The light falling upon any particular part of the photographic plate is modified (1) by the behaviour of oblique rays in the lens, and (2) by the partial obscuration of the diaphragm aperture by the lens-mount, for points beyond a certain distance from the axis. Taking the former of these first, we find that oblique pencils coming through the diaphragm at an angle u with the primary optical axis are given not a circular section with diameter $2a$, but an elliptical section with axes $2a$ and $2a \cos u$, and area $\pi a^2 \cos u$. The flux of light towards the diaphragm-aperture, I_u at an angle u, is therefore equal to $I_o \cos u$, where I_o is the axial flux of light towards the diaphragm. Then as to the illumination on the plate (assuming the lens well corrected), if the beam leaves the lens under an obliquity u^1, the flux of light in the direction of the oblique rays varies as $\cos u$ by reason of the smaller flux through the obliquely illuminated diaphragm aperture, and also as $\cos^2 u^1$ by reason of the greater distance between the diaphragm and the part of the plate illuminated. So that the flux obliquely at angle u^1 is $J^1_u \backsim J^1_o \cos u \cos^2 u^1$ where J^1_o is the axial flux in the direction of the rays. To make this an equation we need a multiplier: but this multiplier will not, on account of the varying effects of absorption and reflection, be the same for all angles of incidence: call it K_u. Further, when d is the diaphragm aperture and f the focal length of the lens, the axial flux J^1_o is d^2/f^2. Lastly the flux incident upon the plate, per unit of area, is $J^1_u \cos u^1 = I^1_u$. Whence

$$I^1_u = \frac{d^2}{f^2} \cdot K_u \cos u \cos^3 u^1.$$

Discussion of the varying values of K_u, taking polarisation into account, leads to the conclusion that K_u is a product of two calculable factors, one relating to absorption and the other to reflection, and that the latter is approximately constant for all angles of incidence within a working angle of about 70° for Zeiss single and double anastigmats series vi., and about 23½° for Petzval portrait combinations. The latter result is obtained with very varying combinations of lenses within fairly wide working

angles, so that reflection does not make any material difference in the illumination produced by direct and oblique rays respectively. As to absorption there is a want of data as to absorption coefficients. (See Krüss, Centralz. f. Optik u. Mech. 11, 1890; Vogel, Sitz.-Ber. d. Berl. Akad. 2, No. 46, 1219–1231, 1896; Wilsing, Astronom. Nachr. 142, No. 3400, pp. 241–252, 1897). Generally, since marginal rays have a longer path in the more absorptive thick-edged flint glass and a shorter path in the less absorptive thin-edged crown, they are more powerfully absorbed than the axial rays: and the larger the scale on which the lens is made, if otherwise similar in form, the greater will be the absorptive effect, the logarithm of the absorption-factor being proportional to the linear dimension of the lens.

But the term $\cos u \cdot \cos^3 u^1$ itself varies according to the type of the lens: for u being half the working angle of the lens (angles of landscape subtended at the anterior nodal-point, or angle of plate subtended at the posterior nodal-point—see Grubb, Brit. Journ. of Photogr. Nos. 166–171, 1869), u^1 varies with u according to the lens used. If $u > u^1$, $\cos u < \cos u^1$, and the fall in the value of $\cos u \cdot \cos^3 u^1$ is relatively small. But simple lenses give barrel-shaped images, for u^1 is itself too small: and this, on the other hand, gives a less rapid fall-off in illumination than a realisation of the proper angle would do. If we take the axial illumination as unity, the corresponding values of $\cos u \cos^3 u^1$ for the ideal lens, in which $\tan u^1$ bears a constant ratio to $\tan u^1$, are as follows: $u = 5°$, 0·9877; 10°, 0·9512; 15°, 0·8927; 20°, 0·8150; 25°, 0·7222; 30°, 0·6193; 34°, 0·5333; whereas with a simple lens the ratios are 0·9877, 0·9515, 0·8942, 0·8193, 0·7317, 0·6368, and 0·5591. With a symmetrical combination the illumination at 34° is 0·4724 times the axial illumination.

If $u = u^1$, the expression becomes $\cos^4 u$. It is possible with symmetrical objectives; and the fall-off in illumination is more rapid than in the preceding case. If $u < u^1$ (asymmetric double objectives, and Petzval) the fall-off is still more rapid. Telephoto lenses come under this category. In general, the greater the distance between the focal plane and the point of apparent emergence the more even is the illumination, since the more nearly does the incidence approximate to the vertical.

The second cause of fall-off in illumination is partial obscuration of the diaphragm-aperture by the mount. With a plain meniscus lens the mount must be larger than the diaphragm, for the marginal rays crossing the axis are turned away from the axis while within the lens. If R be the maximum radius of diaphragm-aperture which allow rays to get past the mount, and r the actual diaphragm-radius employed at any moment, the angle within which there is no obscuration of the diaphragm-aperture is $w = \tan^{-1}(R - r)/d$, where d is the axial distance between the diaphragm and the obstructing edge of the mount: there is about a half obscuration at the angle $W = \tan^{-1} R/d$: and complete

obscuration at the angle $\omega = \tan^{-1}(R+r)/d$. Between the last two angles there are no secondary axial rays passing through. The smaller the diaphragm-aperture the more abrupt is the transition between illumination and darkness. In holosymmetrical systems of two lenses the aperture required is always twice what would serve either of the lenses taken alone. With single and double Zeiss anastigmats of the same size, series vi., the following are the respective angles of view free from obscuration.

Diaphragm-apertures; single combinations f	16·5	18·8	22	26	32
,, ,, double combination f	8·5	9·7	12	14·7	19·8
Angles of unobscured field	5°	10°	15°	20°	25°

A holosymmetrical combination lets no rays through beyond those corresponding to angle W in a simple lens, and the fall-off at the margins of the disc of illumination, so far as due to this cause, is correspondingly more abrupt. The fact of the diminution of illumination towards the margins was noted in the sixties and discussed by Setzval, Bow, Grubb, and Goddard. The effect of the term $\cos u \cdot \cos^3 u'$ cannot practically be prevented: and accordingly the remedy appeared to be to diminish the illumination axially, either by special apertures or by reducing the intensity of the axial rays.

The author gives an account of the remedies suggested in past years by Grubb, Slight, R. H. Bow, De la Noë, and A. Miethe.

A. D.

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245. *Monochromatic Illumination.* **R. Straubel.** (Wied. Annalen, 66. 2. pp. 350–352, 1898.)—The author proposes the use of two prisms in order to produce monochromatic light without turning the collimator or the telescope. The two prisms are mounted face to face, and one of them can be turned in a plane parallel to one of its faces, thus changing the angle and consequently also the dispersion of the prism. E. E. F.

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246. *Magnetic Rotatory Polarisation.* **H. Becquerel.** (Comptes Rendus, 127. pp. 647–651, 1898.)—Reference is made to the recent experiment of MM. Macaluso and Corbino (C. R. 127. p. 548) which was as follows: Through the pierced armatures of an electro-magnet placed between two nicols, was made to pass, parallel to the magnetic field therein, a beam of white light that was analysed by means of a spectroscope of high dispersive power; between the armatures was placed a sodium flame, and when the current was started round the electro-magnet there was seen to appear on each side of the two absorption bands D_1 and D_2 formed in the spectrum, bands alternately dark and bright which are displaced when the analyser is rotated. These bands are due to a phenomenon of magnetic rotatory polarisation; they constitute

on each side of each of the D rays a channeled spectrum, showing that across the sodium flame the radiations which are in the immediate neighbourhood of each absorption band undergo a considerable magnetic rotation which increases in proportion to the nearness of their wave-length to that of the absorbed ray. The author has repeated and extended these observations, and connects them with a result to which he has been led, that the magnetic rotatory powers of bodies must be proportional to a function of their magnetic properties and to the expression $\lambda \frac{dn}{d\lambda}$, in which λ denotes the wave-length and n the corresponding index of refraction. (See 1898, Abstract No. 115.) The phenomenon observed by Macaluso and Corbino would appear to indicate that in the immediate neighbourhood of the bands of absorption of an incandescent vapour the value of $\frac{dn}{d\lambda}$ must be considered as becoming infinitely great. J. J. S.

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247. *Mounting of Rowland Grating.* **W. E. Adeney** and **J. Carson.** (Phil. Mag. 46. pp. 223–227, 1898.)—The well-known mounting described by Ames for the Rowland concave grating spectrometer was adopted, but special provision was added to allow of the instrument being used in an ordinary lighted room, instead of the room acting as the camera as is usually the case when these instruments are used. The ways from the slit to the grating, and from the grating to the camera, were provided with wooden tubes having sliding parts so that when the instrument was adjusted for the part of spectrum required, the whole path of the light could be enclosed.

The arrangement seems perfectly satisfactory, as plates have been exposed for upwards of six hours on bright days without the plates becoming fogged, and of course the accompanying convenience of working in a well-lighted room needs no emphasising. C. P. B.

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248. *Absorption by Uranyl Salts.* **E. Deussen.** (Wied. Annalen, 66. 5. pp. 1128–1148, 1898.)—The author investigates the absorption bands of uranyl salts in various solvents and endeavours to trace connections between their positions and the properties of the solvent. He finds that the various salts show some relation between solubility and absorption, the bands of the more insoluble salts tending towards greater wave-lengths, except the chloride and nitrate in glycerine. Also, the solvent exerts a marked influence upon the intensity of the absorption, as already noticed by Katz in the case of organic pigments. E. E. F.

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249. *Reduction of Prismatic Spectra.* **E. Edser** and **C. P. Butler.** (Phil. Mag. 46. pp. 207–216, 1898.)—The authors employ the rectilinear system of interference bands formed when the beam from a continuous light source, after passing through a thin air film contained between two highly reflective surfaces, is afterwards analysed by a prismatic spectroscope. As shown by Fizeau and Foucault and more recent workers, the prismatic spectrum is under these conditions crossed by bands, the intervals between which depend on the wave-length of the light, and the relative retardation produced by the thin film, *i.e.*, on the thickness of this film. Theoretically the air film should coincide with the plane of the slit of the spectroscope, and various methods were tried to admit of this condition. By sacrificing the perfection due to this, however, it was found that the necessary apparatus and manipulation were immensely reduced, and the adopted plan is simply to support the film as close as possible to the slit-jaws. Except with spectrometers of the highest power it is difficult to detect the inaccuracy introduced.

The air film is obtained by placing two plane parallel plates of glass together, the surfaces in juxtaposition being silvered so that about 75 per cent. of the incident light is reflected. Bands can be obtained without the surfaces being silvered, but Fabry and Perot have demonstrated the greatly enhanced contrast produced by silvering the plates used for interference phenomena.

Examples of the reduction of a spectrum of iron are given, in which it appears that with the fineness of bands they used, the limit of error was not more than 0·5 tenth-metre. Two methods of reduction are shown. First, where only few lines are present, they can be reduced by the simple formula giving wave-lengths direct. Second, where many lines are required, the formula is transposed by substituting the reciprocal of the wave-length, *i.e.* wave frequency, for wave-length, and it is shown that in this case the curve representing the bands becomes a *straight line*, which can be drawn once for all very accurately on a large scale. The frequencies of the various lines can then at once be determined from their co-ordinates with respect to this line. A reproduction of the photograph measured is given in the paper. C. P. B.

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250. *Interferential Spectroscopy.* **Jobin.** (Paris Soc. Franc. Phys. Bull. 116. pp. 7–9, 1898.)—In describing a new instrument made to the design of Fabry and Perot, the author of the present paper brings together many facts from disconnected papers by these two physicists, and the article will be useful in saving the time necessary for reference to the individual papers. C. P. B.

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251. *Ionic Velocities in Röntgenised Gases.* **J. Zeleny.** (Phil. Mag. 46. pp. 120–154, 1898.)—There is a difference of velocity between the positive and negative ions. The method of research is based on opposing a stream of gas to the velocity due to the electric forces. Let H be the velocity of this stream of gas; and let u, v, be the velocities of positive and negative ions respectively under a unit potential gradient, so that the actual velocities of these ions are $u.\ U/d$ and $v.\ U/d$ respectively, where U is the potential difference and d the distance across which it acts. Then if $H = u\ U/d$, the positive ions could be brought to a zero resultant velocity: if the potential difference be adjusted to V so that $H = v\ V/d$, an equal gas velocity H would bring the negative ions to a zero velocity: and then $u/v = V/U$. Experimental difficulties are discussed and apparatus explained. A type of tube is figured (page 126) which has been found to give almost constant Röntgen radiation. The following table gives the ratio between the greater velocity of the negative and the lesser velocity of the positive ion.

Air, N & O	1·24±·005	Carbon dioxide, CO_2.....	1·00+·005
Oxygen, O	1·24±·005	Ammonia, NH_3...	1·045±·015
Nitrogen, N	1·23± ·01	Acetylene, C_2H_2...	0·985±·015
Hydrogen, H ...	1·14± ·01	Nitrogen monoxide, N_2O	1·105± ·01
Coal gas: H and others	1·15± ·01		

When the E.M.F between two plates is alternating, the Röntgenised air between has its positive and negative ions put into oscillation; but the negative ions are drawn towards the plates from greater distances than are the positive ions and they gather near the plates while the central bulk of the gas becomes positively charged, so that if blown upon a conductor it will charge this. But if the distance between the plates be reduced to the amplitude of the oscillation made by each positive ion at each alternation of the E.M.F., there is no such separation, and the air when blown upon a conductor does not charge it. This gives a datum for ascertaining the actual velocity of positive ions. A metal placed in air which is, or recently has been, exposed to Röntgen radiation receives a negative charge while the air itself remains positively electrified; for the negative ions more rapidly diffuse towards the metal than the positive do, and a larger number of positive ions are left in the air. Sufficient time must be allowed for this action, but too much time tends again to equalise matters. With carbonic acid, in which the ion-velocities are equal or nearly so, this effect is inappreciable. Air charged negatively discharges faster to a surface than when charged positively (Rutherford); a consequence of the greater velocity of the negative ions. The distribution of electrification and the true local potential-gradients in a gas between two plates are discussed. As the difference of

potential increases, the charge at the plates increases and also the charged area or volume of gas increases, the charged ions not being now gathered at the respective plates. A polarisation effect has been obtained. The differences in the velocities point towards differences in the sizes of the ions. A. D.

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252. *Röntgen Rays and Spark Discharges.* **H. Starke.** (Wied. Annalen, 66. 5. pp. 1009–1013, 1898.)—Röntgen rays reduce the retardation of spark discharges, just as ultra-violet rays do. The maximum effects of the two kinds of radiation nearly coincide. They probably consist in the total elimination of the retardation. E. E. F.

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253. *Visibility of Röntgen Rays.* **E. Dorn.** (Wied. Annalen, 66. 5. pp. 1171–1176, 1898.)—Experiments with a totally colour-blind person show that a colour-blind eye may be very sensitive to Röntgen rays. In the case described, the rays appeared of a nearly blinding intensity to the subject, while they were only faintly luminous to the ordinary eye. A number of experiments were made to test whether the rods or the cones of the retina were the sensitive organs in the case of X rays. The results showed that the rods are more sensitive than the cones, although the latter also perceive the rays to a lesser extent, as is proved by the sensitiveness of the yellow spot, which contains no rods. E. E. F.

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254. *Becquerel Rays.* **J. Elster** and **H. Geitel.** (Wied. Annalen, 66. 4. pp. 735–740, 1898.)—The authors have endeavoured to discriminate between the theories which attribute the origin of uranium and thorium rays to the absorption of molecular energy, to the absorption of a kind of transcendental rays, and to chemical action respectively. They used the highly efficient uranium pitch ore of Joachimsthal for the purpose. They first tried it in a vacuum, but without detecting any difference in its behaviour. Then they took the substance to the bottom of a mine, 850 m. below the surface, but without effect. If the molecular or chemical theories had been true, a difference should have been shown in a vacuum. If the rays postulated by Curie exist, they would probably not penetrate 3,000 feet of rock. The negative results leave the question open for solution. E. E. F.

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255. *Photographic Action of Living Structures.* **P. Frankland.** (Chem. News, 78. p. 186, 1898.)—An account is given of experiments which show that ordinary bacterial cultures are capable of affecting photographic films, even at a distance of half an inch, whilst when placed in contact with the film definite pictures of the bacterial growths are obtained. As this action does not take place through glass it is considered due to the evolution of volatile chemical substances which enter into reaction with the sensitive film. Bacterial growths which are luminous in the dark exert a much more powerful action on the photographic plate than non-luminous bacteria, and this action can take place although a glass plate is interposed. J. J. S.

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256. *Photographic Action of Gases and Metals.* **B. von Lengyel.** (Wied. Annalen, 66. 5. pp. 1162–1170, 1898.)—Reducing gases like hydrogen have an effect upon photographic plates similar to that of light, since they produce a modification of silver bromide which is easily reduced by the ordinary developers. The effect of metals like zinc, platinum, and palladium is explained by the fact that they liberate hydrogen from moist air and thus indirectly influence the photographic plate. Uranium and thorium compounds alone give out a radiant energy.

E. E. F.

HEAT.

257. *Dalton's Law.* **W. N. Shaw.** (Chem. News, 78. p. 185, 1898.)—Discrepancies between the sum of the partial pressures of air or nitrogen and saturated vapour, and the pressure of mixtures of the gases respectively with saturated vapour, indicating an apparent departure from Dalton's Law, were shown by Regnault to exist for water vapour; the extent of the difference being on the average nearly 0·5 mm. Regnault attributed the phenomena to the condensation of the vapour on the vertical sides of the containing tube under a pressure of vapour less than the saturation pressure corresponding to the temperature. The author discusses Regnault's explanation, and concludes that it is probably an unreal one, and that an actual divergence from Dalton's Law is indicated. The amount of the divergence, however, cannot be finally deduced from the records of Regnault's observations, and must await a repetition of such experiments in which the errors which may be due to super-saturation are guarded against. J. J. S.

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258. *Low Temperature Specific Heats.* **U. Behn.** (Wied. Annalen, 66. 2. pp. 237–244, 1898.)—Dulong and Petit's law is departed from in the case of metals more and more as the temperature falls. Between $-80°$ and $-180°$ the atomic heats, instead of ranging about 6·3, vary from 6·0 (lead) to 4·0 (iron). The decrease in the specific heat is greatest in those metals which have a high specific heat at high temperatures. This indicates the possibility of all metals having the same specific heat at the absolute zero. That specific heat is probably itself zero.

E. E. F.

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259. *Specific Heat of Liquids.* **E. Gumlich** and **H. F. Wiebe.** (Wied. Annalen, 66. 3. pp. 530–534, 1898.)—The Andrews-Pfaundler method of determining specific heats of liquids by immersing in them a hot bulb containing mercury, and allowing it to give off heat to the liquid until the mercury has attained a certain position in the stem of the bulb, is subject to the error that though the mercury may have apparently fallen through the same range of temperature, the final temperatures of the two liquids compared may not be the same. Hence the contraction and capacity of the glass vessel is different, and affects the position of the mercury. E. E. F.

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260. *Variation of γ with Temperature.* **A. Leduc.** (Comptes Rendus, 127. pp. 659–662, 1898.)—The numerical results of a former paper (see 1898, Abstract No. 383), are here slightly corrected and augmented. The second column represents the speed of sound in decimetres per second, and the third the ratio γ of the isopiestic and isometric specific heats.

Air at 0° C.	3318	1·4040	CO at 0°	3370	1·401
„ 100° C.	3878	1·4031	N_2O „	2596	1·324
CO_2 at 0° C.	2593	1·3190	NH_3 „	4159	1·336
„ 100° C.	3002	1·2827	C_2H_4 „	3158	1·250

Thus, though γ falls for CO_2 as the temperature rises, it scarcely varies for air; for a perfect diatomic gas $\gamma=1·4$; for a perfect triatomic gas $\gamma=\frac{4}{3}$. The author proposes to show later that in the last case $\gamma=1\times\frac{2}{3}\cdot\frac{4}{10}=1·267$, and that $\gamma=\frac{5}{3}$ does not characterise a perfect monatomic gas. R. E. B.

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261. *Mechanical Equivalent of Heat and Specific Heats of Gases.* **A. Leduc.** (Comptes Rendus, 127, pp. 860–862, 1898.)—Calculating J from the equation $J\,(C-c)=T\,(dp/dt)\,(dv/dt)$ with the characteristic given by equations (5) and (4) of Abstract No. 383, 1898 (the functions occurring in which are defined in Abstract No. 300, 1898), and using his previously obtained values for air, viz., $\gamma_0=1·404$, $\gamma_{100}=1·403$, $C_0=C_{100}=·239$ (see 1898, Abstract No. 1234) the author obtains for $J.10^{-6}$ the values 41·94 from air at 0°, and 41·84 from air at 100°, or in the mean, 41·89. Applying this result to CO_2 with the values $\gamma_0=1·319$, $\gamma_{100}=1·283$, he finds $C_0=0·193$, $C_{100}=0·207$; the former lies between the values given by Regnault and Wiedemann, but the latter is considerably less than either. R. E. B.

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262. *Thermal Properties of Gases and Liquids.* **S. Young.** (Chem. News, 78. pp. 200–201, 1898. Rep. Brit. Assoc. 1898, pp. 831–834.)—The ratio of the actual density of a saturated vapour to its theoretical density should, on van der Waals' theory, be the same for all substances at corresponding pressures, and at the critical point should, with O. E. Meyer's correction, be $\frac{8}{3}\times\sqrt{2}=3·77$. Twenty-six substances were examined, and they grouped themselves as follows: for benzene, its four monohaloid derivatives, ether, the tetrachlorides of carbon and tin, and four paraffins, this ratio at the critical point is in the mean 3·77; for ten esters it varies from 3·87 to 3·95; for the lowest three alcohols it is from 4·02 to 4·52; and for acetic acid it rises to 5. This points to polymerisation at the critical point to a less or greater extent.

An accurate experimental determination of the critical specific

volume cannot apparently be obtained : it may be estimated on the assumption of Cailletet and Mathias' law of diameters, viz., that the mean of the densities of a saturated vapour and its liquid is a linear function of the temperature, which was confirmed for all the compounds examined except the alcohols. The experiments furthermore confirmed the view, which of late has been contested, that the vapour pressure of a *pure* substance is independent of the relative volumes of liquid and vapour present.

R. E. B.

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263. *Kinetic Theory of Liquids.* **C. Dieterici.** (Wied. Annalen, 66. 5. pp. 826–858, 1898.)—This work is an attempt to formulate a kinetic theory of liquids. It is the result of a conviction as to the possibilities of bringing the principles of the new theory of solutions into harmony with the well-established theorems of the kinetic theory of gases. Those attempts which have been hitherto made have often led to contradictory results. On closer examination, the contradictions turn out to be only apparent, but this does not become evident until the observations are numerically compared with the theoretical equations, and hence the present work is not so much a mathematical theory as an empirical calculation concerning the necessary theoretical foundations. In the first three divisions the liquids are treated as ideal gases, and the calculations familiar from the kinetic theory of such gases are applied to liquids. The conclusions resulting as to vapour pressure and heat of vaporisation do not agree with actual facts. The author therefore discusses the various possibilities of amplification and shows that only the considerations of space extension of the molecules, first introduced by van der Waals, are capable of leading any further. But this is only made possible by attaining a more definite conception of the mechanism of evaporation, in which the author assumes the molecules to be infinitely hard, or constructed so that the effects of impact are propagated through the mass of a molecule in an infinitesimal time. The expression for the heat of evaporation thus obtained has a clear and definite sense, and corresponds very fairly with experience. Also, it admits of an immediate application to solutions and leads to a kinetic theory of osmotic pressure, the most important quantity in the new theory of solutions. A numerical calculation of the expressions and their application to experimental results is, however, attended with difficulties, and can only be carried out when further information is obtained with regard to the size of the molecules of both the solvent and the solute. A further development of the author's attempt will, of course, introduce emendations of the suppositions made, but he at least succeeds in showing that even with our present knowledge a treatment of liquids according to the kinetic theory of gases is possible, and leads to tangible results. E. E. F.

SOUND.

264. *Circular Chladni Plates.* **J. Zenneck.** (Wied. Annalen, 66. 1. pp. 170–176, 1898.)—The sand figures obtained with Chladni plates differ from those obtained by theory owing to lack of perfect symmetry of the plates used. There are always two definite positions of the radial nodal lines in which a simple vibration, free from beats, may be obtained with stationary lines. The lines in one chief position bisect the angles between the lines in the other chief position. If the radius originally fixed does not happen to coincide with one of these chief positions, both systems of lines occur at the same time, and begin to oscillate about the nearest chief position. If the plate is capable of rotating, the plate itself oscillates, or at all events it turns slowly in one direction, and returns as the vibration dies out. E. E. F.

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265. *Tuning Plates.* **F. Melde.** (Wied. Annalen, 66. 4. pp. 767–780, 1898.)—In order to avoid the difficulties attending the measurement of the pitch of high tuning-forks and even their theoretical values, the author substitutes small and thick circular Chladni plates capable of giving notes up to 30,000 vibrations per second. The pitch may be accurately calculated from the dimensions by Chladni's formula. The only difficulty remaining is to prove that the plate vibrates at all, since the ear is incapable of perceiving notes of the highest pitches. The author uses his resonance method, which consists in transferring the vibrations by means of a lever to a rod or a membrane, on which the vibrations are indicated by nodal lines or circles. He finds the theoretical and experimental values to agree within about 2 per cent.

E. E. F.

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266. *Velocity of Propagation of Discontinuities.* **P. Vieille.** (Comptes Rendus, 127. pp. 41–43, 1898.)—On sharpening the explosion of fulminate by tightly packing it, the velocities of propagation rise to 1100 metres in air, 800 in carbonic acid, and 2000 in hydrogen, with a charge of 0·63 gramme of fulminate. This velocity rapidly falls off as the wave travels, and the impact of the wave loses its original percussive character. A. D.

ELECTRICITY.

267. *Theories of Lorenz and of Larmor.* **A. Liénard.** (Écl. Électr. 16. pp. 360–365, 1898.)—Liénard points out certain difficulties to which in his view Larmor's theory is subject. If A B C denote components of magnetisation, $\alpha\ \beta\ \gamma$ those of magnetic force, $a\ b\ c$ those of magnetic induction, of any system of magnets, the energy of system (1) in the field of system (2) is

$$-\int(A_1\alpha_2+B_1\beta_2+C_1\gamma_2)\ d\omega$$

over all elements of volume $d\omega$. In this he substitutes for A B C from the known relations $a=\alpha+4\pi A$, &c.

It is then proved that

$$\int(a_1\alpha_2+b_1\beta_2+c_1\gamma_2)\ d\omega=0$$

Whence he obtains for the energy in question the two equivalent expressions—

$$\frac{1}{4\pi}\int(a_1\alpha_2+\beta_1\beta_2+\gamma_1\gamma_2)\ d\omega \qquad (1)$$

and

$$-\frac{1}{4\pi}\int(a_1a_2+b_1b_2+c_1c_2)\ d\omega \qquad (2)$$

It follows that the energy of a system of magnets may be put in the form

$$W=\frac{1}{8\pi}\int(a^2+\beta^2+\gamma^2)\ d\omega \qquad (1)$$

When we pass to the equivalent currents, the components of magnetic induction $a\ b\ c$ have, according to M. Liénard, the same value for the currents as for the magnets, and the energy of the system of currents is

$$W=\frac{1}{8\pi}\int(a^2+b^2+c^2)\ d\omega \qquad (2)$$

It is then shown that the two values of W differ by the constant

$$2\pi\int(A^2+B^2+C^2)\ d\omega$$

Liénard says that according to Larmor's theory the system of magnets and that of the equivalent currents have energies of the same sign.

To overcome the difficulty he suggests that the elementary molecular currents are not, as in Larmor's theory, rigorously

constant, but are subject to induction. He then considers the effect from this point of view of Larmor's theory that the molecular currents are currents of convection of moving ions or electrons. Lorenz's theory, according to M. Liénard, is not subject to this difficulty.

Next is considered Larmor's view that the magnetic field produced by the displacement of an ion is an indirect effect of the Maxwell current of displacement $f\ g\ h$. A charged body symmetrical about an axis revolves with uniform velocity. The displacement is then constant and there should, according to Larmor, be no magnetic field. But this does not agree with Rowland's experiment. Liénard criticises Larmor's method of avoiding this difficulty, which, he says, does not affect Lorenz's theory. S. H. B.

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268. *Irreversible Radiation.* **M. Planck.** (Berlin, Akad. Sitzber. 34. pp. 449–476, 1898.)—In his former communications on this subject (see 1898, Abstract No. 631) Planck investigated the concentric electromagnetic waves in a hollow sphere bounded by a reflecting surface at the centre of which is a small resonator. The resonator, absorbing and emitting energy, affects the radiation, and in an irreversible way, because the oscillations of intensity are generally less for the emitted than for the entering waves. Certain classes of waves have to be excluded from consideration. The conception is introduced of "natural" radiation which always goes on irreversibly.

It is necessary for this conception to introduce the radiation intensity for a defined wave-length. Planck discusses this question.

In the fourth section is investigated the intensity of the radiation inwards and outwards, and the energy of the resonator.

In the fifth section the intensity of radiation belonging to waves of given wave-length.

In the sixth section he discusses the relations between the vibration of the resonator and the intensities of the radiation inwards and outwards. He defines the "natural" radiation. The criterion of irreversibility is that there should exist a function whose value is completely determined by the state of the system at any instant, and whose rate of change with the time is always of the same sign, that is an entropy function. Such a function is proved to exist for Planck's radiations. S. H. B.

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269. *Capacity of Two Spheres in Contact.* **R. H. Jude.** (Phil. Mag. 46. pp. 254–258, 1898.)—This note discusses the valuation of Maxwell's expression for the electrostatic capacity of two spheres in contact. This cannot be effected by ordinary algebraic methods except when the diameters of the spheres are

equal. The author here obtains the desired summations in terms of the *Eta Function* as follows :—

$$\frac{Q_a}{V}=\frac{a\,b}{a+b}\,H\left(\frac{b}{a+b}\right); \qquad (1)$$

$$\frac{Q_b}{V}=\frac{a\,b}{a+b}\,H\left(\frac{a}{a+b}\right); \qquad (2)$$

and of course

$$C=\frac{Q_a+Q_b}{V}; \qquad (3)$$

Where the Q's denote the charges on the spheres of radius a and b, V their common potential, C the capacity of the pair and the Eta Function is defined by the equation

$$-H(n)=1-\frac{1}{n}+\frac{1}{2}-\frac{1}{n+1}+\frac{1}{3}-\frac{1}{n+2}+ \qquad (4)$$

E. H. B.

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270. *Capacity of Wires.* **W. Moon.** (Elect. Rev. 43. pp. 478–480, 1898.)—The limits of the capacity of multiple cables can be stated; thus the capacity between a wire X and a number of other wires and the earth cannot be as great as twice the capacity between X and the nearest wire. In the case of wires on poles, the capacity between X and the remaining wires and earth is not as great as that between X and an infinite plane at the distance of the nearest wire. The capacity between one wire and any system of wires and the earth could in no case be as great as twice the capacity between one wire and the earth. In a perfect telephone looped circuit, the effective capacity of one wire may be taken as the sum of the capacity of either wire with the remainder and earth, and the capacity between the two wires and the loop. M. O'G.

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271. *Influence of Mechanical and Electric Stress on Capacity.* **U. Panichi.** (N. Cimento, 8. 4. pp. 89–96, 1898.)—An increase of specific inductive capacity with traction has been deduced from theory by Lippmann, and found experimentally by Dessau; Cantone, on the other hand, has shown that a decrease of dielectric constant ought to occur in a direction normal to that of traction, and this has been verified by Corbino. The author has examined the changes of volume produced by traction and by electric charge respectively, in a condenser consisting of a cylindrical tube of ebonite, separating two coatings of mercury; he has also investigated the relation between the stretching force and the consequent variation of specific inductive capacity. It is found that the change of volume of the dielectric is proportional to the stretching force applied. The electric charge from a Holtz

machine produces small increases of volume, which are slightly greater when the condenser has been charged for some time; the volume becomes constant after about five minutes' charging.

For experiments on the effect of stress on specific inductive capacity, the condenser is charged from 150 Daniell cells; it is then connected with an electrometer and stretched by various weights. The readings of potential indicate that the inductive capacity of ebonite diminishes with traction, and, within the limits of the experiment, proportionally to the traction. J. L. H.

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272. *Dielectric Constants.* **J. A. Erskine.** (Wied. Annalen, 66. 2. pp. 269–283, 1898.)—If C_1 and C_2 are capacities inserted in a primary and a secondary circuit respectively, and i_1 and i_2 the currents, the author proves that i_2 changes very rapidly with C_2 when C_1 has certain values. Hence, if a suitable current indicator is available, the mutual influence of two circuits may be used for comparing two capacities with great accuracy, and hence also for the determination of dielectric constants. Such an indicator the author found in a set of magnetised bits of steel wire, only 1 cm. long. The primary current consisted of the discharge of an influence machine. The unknown capacity was determined by measuring the distance between the plates of a Kohlrausch condenser, when that and the condenser of unknown capacity produced the same demagnetisation of the needles. E. E. F.

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273. *Contact Electricity.* **A. Heydweiller.** (Wied. Annalen, 66. 3. pp. 535–539, 1898.)—The author tests Coehn's rule, according to which a body with a higher dielectric constant is positively charged by contact with a body of a lower dielectric constant, for liquids and solids, by introducing minutely subdivided metals into a narrow tube containing an electrolyte, made up of a mixture of water and acetone, or acetone and alcohol, in proportions suitable for obtaining a definite dielectric constant between 5 and 70. The contact electrification between the metal and the liquid is indicated by the motion of the metallic fragments in the tube on passing the current. Platinum shows electrification in pure chloroform, but negative in all other dielectrics. Gold, tin, cadmium, zinc, and aluminium are increasingly positive. An exception to Coehn's rule occurs in the alcohols and in amyl acetate. E. E. F.

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274. *Point Discharges.* **K. Wesendonck.** (Wied. Annalen, 66. 2. pp. 341–345, 1898.)—One terminal of a Voss machine is put to earth, while the other leads to a spark gap, beyond

which a fine needle is attached to the wire, which is also put to earth. Opposite the needle-point is mounted a plate connected with an electroscope, the outer cover of which is put to earth. On working the machine the plate is always charged positively, as in Tesla's corresponding experiment. On introducing a suitable self-induction, however, the plate is charged with the same charge as that of the terminal used. The difference between the two cases may be strikingly shown by introducing a closely wound coil of wire as a self-induction, and then pulling out the coil to a greater length, thus lessening its inductance. The author explains the effect by assuming that the negative discharge suffers more retardation than the positive discharge. E. E. F.

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275. *Point Discharges.* **E. Warburg.** (Wied. Annalen, 66. 4. pp. 652–659, 1898.)—Let a needle-point be mounted opposite a metallic surface earthed through a galvanometer. If the needle-point is then maintained at a potential which exceeds a certain value the galvanometer indicates a constant current traversing the air between the point and the metallic surface. The author asks what time elapses between the establishment of the proper difference of potential between needle-point and surface and the passing of the discharge. He mounts a fine platinum point in the centre of a nearly closed metallic sphere, and determines the current after various intervals of charging. He finds that the discharge attains its full value 0.007 secs. after establishing the proper difference of potential, and that, therefore, the air does not require more than that short interval to acquire its full conductivity. The retardation which attends spark discharges between spheres is not observed in this case. E. E. F.

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276. *Stratified Brush Discharge.* **M. Toepler.** (Wied. Annalen, 66. 4. pp. 660–675, 1898.)—A spark gap and a large liquid resistance are inserted in the circuit of a 60-plate Toepler machine, the capacities in the circuit being kept small. Then, while the current is feeble, the discharge takes the form of the ordinary brush discharge. When the current strength attains a certain minimum limit the brush discharge is displaced by a stream of sparks. Instead of the low humming, a rattling sound is heard, rising in pitch as the current increases. On reaching a certain higher limit a nearly continuous brush light arc takes the place of the spark discharge, characterised by a great evolution of heat and by a stratification resembling that already described by the author in the case of a large battery of Leyden jars. This brush light burns almost noiselessly. A further increase in the current strength does not produce any further change. On gradually reducing the current the same phenomena are noticed

in the reverse order. Experiments with various gaps show that the lower limit between brush and spark discharges is nearly independent of the size of the gap, but when the current falls below a certain small minimum value none but spark discharges can be produced, however large or small the gap. If the anode is pointed the brush-light arc consists of bright, whitish-violet kathode light, a second layer of brick-red light, scarlet positive light, and anode glow light. The analogy between open-air and vacuum discharges is further strengthened by the fact that the Wiedemann-Hittorf law of vacuum discharges, according to which the difference of potential at which discharge sets in is independent of the current strength, also holds for these open-air discharges. E. E. F.

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277. *Magnetic Deflection of Discharges.* **J. Precht.** (Wied. Annalen, 66. 4, pp. 676–697, 1898.)—Magnetic deflection is observed not only in vacuum discharges, but also in open-air spark, glow, and brush discharges. If the anode is pointed, and the kathode blunt, the length of gap 8 mm., and the difference of potential 8,600 volts, a field of 7,000 units produces a very decided deflection of the path of the sparks, accompanied by a fall in the potential by about 1,000 volts. The deflection is limited to that portion of the spark which lies between the centre and the kathode, and is accompanied by an increase of brightness. When the gap is widened, brush discharge sets in, but the spark discharge is restored by a strong magnetic field. On still further widening, the brush discharge is re-established, but the magnetic field alters the oval shape of the brush, and concentrates it into the equatorial plane. At the same time a plane anode is strongly etched. E. E. F.

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278. *Frequency of Electric Sparks.* **B. Walter.** (Wied. Annalen, 66. 4. pp. 636–648, 1898.)—The author mounted a sensitive plate upon a little car moving on rails and driven by a falling weight. The rotary interrupter of the induction coil was worked at such a rate that at least two sparks were recorded on the moving plate. This, while ensuring a record, also furnished a measure of the time. The records all agree in showing several successive discharges at intervals of $2{\cdot}7 \times 10^{-4}$ sec. The successive partial discharges, though all in the same direction, show an alternate weakening and strengthening, due to the surging of the primary current in the condenser. Further analysis shows that every spark is preceded by several brush discharges. Each brush discharge is separated from the preceding one, which is usually of the opposite sign. These brush discharges, also seen in lightning photographs, appear as small appendages to the main spark in the ordinary photographs. They serve as pilots for the spark discharge. E. E. F.

279. *Gliding Sparks on Glass.* **M. Toepler.** (Wied. Annalen, 66. 5. pp. 1061–1080, 1898.)—Spark discharges may be made to pass along surfaces of gypsum, water, lampblack, metallic powders, and other substances. Those passing along glass surfaces have the advantage of always passing under practically the same conditions, since even the roughening of the surface by strong sparks does not sensibly affect them. Hence such gliding sparks serve well to show the influence of various kinds of electric discharges upon the length of spark obtainable. The author distinguishes two kinds of gliding sparks. The first kind is produced by a single application of the requisite difference of potential to the electrodes. The second kind is due to the application of a rapidly oscillating E.M.F. The glass surface must be perfectly clean. Two needle-points are pressed upon it, one of them connected with a strip of tinfoil stuck under the plate and reaching from that point to a place opposite the other needle-point. As the length of spark increases, the additional potential required to extend it by another cm. becomes less and less. To obtain gliding sparks of the second kind, the author mounts a high-set inductance in parallel with the glass plate. In this case the increase in spark-length is proportional to the increase of potential. E. E. F.

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280. *Potential Gradients in Vacuum Tubes.* **E. Wiedemann and G. C. Schmidt.** (Wied. Annalen, 66. 2. pp. 314–340, 1898.)—The authors investigate the influence of the source of current, of heat, magnetism, ultra-violet light, and the photo-luminescence of the gas itself upon the potential gradient in a vacuum tube. They find that the luminous appearances are characteristic of the discharge potential, even under very diverse conditions. The potential gradient in the positive light column is largely independent of the width of the tube and the type of the discharge. Ultra-violet light and photo-luminescence are practically without effect upon the potential gradient. The heating effects in the glow light are quite out of proportion to the potential gradient there, probably owing to the fact that some rays are produced at the kathode and absorbed in the glow light. E. E. F.

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281. *Air under powerful Electric Stress.* **J. Trowbridge.** (Phil. Mag. 46. pp. 243–245, 1898.)—Experiments on air exposed to an E.M.F. of about 3,000,000 volts are described. The initial resistance of air under this stress is found to be greatly reduced. The curve expressing the relation between spark-length and the E.M.F. departs from a straight line beyond 1,200,000 volts and approaches the axis expressing the potential difference. The extreme length of spark in air which was obtained was $6\frac{1}{2}$ feet, whereas a length of 10 feet would have been reached if

the spark-length had remained proportional to the potential difference. This departure from proportionality is due to the increased conducting-power of the air. The initial resistance of highly rarefied media also diminishes in a similar manner.

J. J. S.

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282. *Magnetic Deflection of Kathode Rays.* **W. Kaufmann.** (Wied. Annalen, 66. 4. pp. 649–651, 1898.)—In reply to certain criticisms advanced by A. Schuster, the author emphasises the probability that the whole of the electric energy in a vacuum tube is converted into kinetic energy, and the importance of repeating the experiments hitherto made for the determination of e/m with the greatest attainable accuracy. E. E. F.

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283. *Reaction Pressure of Kathode Rays.* **E. Riecke.** (Wied. Annalen, 66. 5. pp. 954–979, 1898.)—The investigations were carried out by means of a radiometer whose vanes were made into kathodes. The motion of the latter in coming to rest after the current had been interrupted was particularly noted, in order to gain an idea of the resistance which they had to encounter in revolving. The reaction pressure was found to be proportional to the current strength. The latter was furnished by a 40-plate Toepler influence machine, which gave a current of about 3×10^{-6} electrostatic units. The reaction pressure was 0·04 c.g.s. units. When the pressure is calculated from the heat of impact of the particles upon the glass wall, it comes out as 0·07 units.

E. E. F.

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284. *Attenuation of Electric Waves along a line of Negligible Leakage.* **E. H. Barton.** (Phil. Mag. 46. pp. 296–305, 1898.)—This paper gives the results of an experimental determination of the attenuation of high-frequency waves along a line practically devoid of leakage and compares the value found with that deducible from the theories of Heaviside and Rayleigh which are approximately applicable to the case. When there is no leakage the theoretical attenuating factor is $e^{-R'x/2Lc}$, where R' is the effective resistance and L the inductance of the pair of wires per unit length, x the distance along the line in cm., and c the speed of light. Rayleigh's high-frequency formula for an isolated wire and a simple harmonic wave train uniformly maintained gives for the present case $\frac{R'}{R} = 31{\cdot}6$, R being the resistance to steady currents. The experimentally determined value of the attenuation factor, viz., $e^{-0{\cdot}0000132x}$, is about double that which would be expected on the theories just quoted. The possibility of

errors in the experiment are discussed and shown to be probably negligible. It is then remarked (1) that in the line used the wires are side by side 8 cm. apart instead of being each isolated, and (2) that the train of waves passing along them is rapidly damped as the primary oscillations die out instead of being maintained of constant amplitude. It thus appears probable that the required modifications of the theory would yield a value of the attenuation more nearly in accord with the experimental one.
AUTHOR.

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285. *Electric Oscillations.* **M. Abraham.** (Wied. Annalen, 66. 3. pp. 435–472, 1898.)—A full treatment of the fundamental and higher oscillations of a straight rod by Maxwell's electrodynamic theory. E. E. F.

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286. *New Form of Hertz Experiments.* **J. Precht.** (Wied. Annalen, 66. 5. pp. 1014–1019, 1898.)—When a constant current from an influence machine is passed between a pointed anode and a blunt kathode, and the electrodes are separated to such an extent that only a faint glow discharge passes, that glow discharge may be converted into a shower of sparks by breathing up the spark gap. A similar effect is obtained by means of electromagnetic waves received by a parabolic mirror, when the resonator sheets are put in metallic connection either with the electrodes, or with two wires mounted very near the kathode, so that small sparks may pass from either of them to the blunt kathode. The spark gap then forms a sensitive instrument for the detection and demonstration of the classical Hertz effects. It has the further advantage of returning at once to its previous condition when the waves cease to impinge upon it. The effect is quite distinct from that of ultra-violet light. At the time that the glow discharge is replaced by a spark discharge, the difference of potential is considerably reduced between the electrodes. This is indicated by an electrometer connected in parallel, and serves to make the effect of the waves still more evident. E. E. F.

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287. *High-Frequency Oscillators for Electro-therapeutic Purposes.* **N. Tesla.** (Elect. Engin. N.Y. 26. pp. 477–481, 1898.)—Arrangements are described by which the oscillatory discharge of a condenser, charged by a high-frequency alternator, may be sent through the primary circuit of an induction coil. The terminals of the secondary circuit are applied to the body of the patient, or one of them may be left insulated. The induction coil differs from the ordinary form, having circuits of very small resistance and few turns. The author also describes a rotary make and break capable of charging and discharging a condenser

10,000 times per second; the contacts are made by directing a stream of mercury against a metal disc carrying thin contact-blades. J. L. H.

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288. *Electric Dispersion.* **K. F. Löwe.** (Wied. Annalen, 66. 3. pp. 390–410, and 4. pp. 582–596, 1898.)—For a number of esters of benzoic acid and the fatty acids the author obtains nearly the same dielectric constants for slow oscillations as Drude found for much more rapid ones. But they are smaller than those found by Tereschin. The dielectric constants of a number of organic substances possessing anomalous electric dispersion are generally much higher for slow than for rapid oscillations. The anomalous electric absorption calculated after Drude from the dispersion of the dielectric constant corresponds closely with the observed values. The electric dispersion of glasses is in general anomalous, but is much less than that quoted by J. J. Thomson. Starke's method of determining dielectric constants by immersion must be limited to bodies whose electric conductivity does not exceed a certain value indicated by theory.

E. E. F.

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289. *Electric Dispersion.* **E. Marx.** (Wied. Annalen, 66. 3. pp. 411–435 and 4. pp. 597–622, 1898.)—Very short electric wire-waves may be obtained by loosening the coupling of the primary and secondary system so that the oscillations due to the primary alone may be observed. The author thus obtained distinct and easily manipulated wire-waves not exceeding 4 cm. in length. He succeeded in mapping out completely the electric dispersion in water, benzol, and ethyl alcohol. Benzol only shares a single absorption band, from which the inductance of the benzol molecule can be calculated. In the electric spectrum of water the maxima and minima of the refractive index occur approximately in double octaves. In ethyl alcohol, a difference in the concentration of 1 per cent. may mean a change in the square of the electric refractive index by 35 per cent. Its dispersion may be approximately represented by a formula in which its proper oscillation is entirely neglected. E. E. F.

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290. *Polarised Electromagnetic Waves.* **K. Waitz.** (Wied. Annalen, 66. 2. pp. 308–313, 1898.)—The author's observations differ somewhat from those of Latrille (see 1898, Abstract No. 1210). According to the latter, the electromagnetic energy transmitted by a metallic slit always increases in proportion to the length of the slit. Waitz, on the other hand, finds a periodic increase and diminution as the length of the slit is enlarged. The minima are very pronounced, and closely approach zero. A

maximum transmission occurs when the stationary wave at the slit has the same length as the resonator and electrometer combined. The first minimum occurs at a length of slit which is double that of the first maximum. The slit vibrates in two halves, and there is a node at the centre. When the resonator is displaced towards the end of the slit, so as not to be at the node, the deflection of the electrometer increases. E. E. F.

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291. *Electromagnetic Waves and Conductivity of Selenium.* **B. Agostini.** (N. Cimento, 8. 4. pp. 81–89, 1898.)—The ends of a glass tube of 1·5 mm. diameter are closed by copper electrodes, enclosing between them fragments of amorphous selenium. By prolonged heating and slow cooling the selenium is crystallised and the tube is then inserted in one arm of a Wheatstone's bridge. Exposure to light diminishes the resistance to nearly half the value in the dark, namely from 110,000 to 62,000 ohms. The tube is then placed at the focus of a parabolic mirror which receives parallel rays from a second parabolic mirror having a Righi oscillator at its focus; the waves used are of short length. The results show that the conductivity of the selenium sometimes increases and sometimes decreases on exposure to the electromagnetic waves; the variation observed is exceedingly small in amount and may be due to errors of observation. The change of resistance is not produced as suddenly as in the case of light and the original resistance is not recovered so quickly when the radiation ceases; the variations observed may therefore be the result of temperature-changes during the experiments. J. L. H.

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292. *Coherers.* **E. Aschkinass.** (Wied. Annalen, 66. 2. pp. 284–307, 1898.)—The view of the action of a coherer according to which minute sparks weld the coherer particles temporarily together, does not account for the anomalous behaviour of PbO_2 powder, whose resistance is greatly increased by the influence of electric radiation. Further, when the air is exhausted from a coherer tube to such an extent that all spark discharges cease to pass, its sensitive reaction takes place as before, though the spark explanation hardly holds good. A chemical action is rendered improbable by the fact that chemically cleaned copper gives a good coherer action. The only advantage of a layer of oxide is that the pressure under which the particles are packed may be varied within wider limits. A gentle heat restores the high resistance, though the contrary effect might be expected. This action is also as yet unexplained. E. E. F.

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293. *Coherers.* **O. Behrendsen.** (Wied. Annalen, 66. 5. pp. 1024–1029, 1898.)—The failure of coherers to detect and correctly indicate ordinary Hertzian vibrations is due to their extreme sensitiveness. When working with them, all single wire lengths should be avoided, and conductors always arranged on the telephone principle, since quite short lengths of a single wire are likely to absorb the waves. In order to study the reflection of electric waves at a wall, and the formation of stationary waves, the author used a coherer of powdered arc carbon. Such a coherer never has an infinite resistance, and it alters by different amounts according to the strength of the impinging wave. The author also describes a beautiful interference experiment made with a nickel coherer. The latter was mounted at a distance of 15 cm. behind a sheet of tinfoil containing two horizontal slits 8 cm. long and 3 mm. wide, which were 1 cm. apart. On working a small exciter stationed 3 or 4 m. from the sheet on the other side, the coherer tube reacted when in a horizontal position. On being raised or lowered by 1 cm. the tube ceased to react, thus indicating a dark interference line. This line was followed by a "bright" space, and that again by another interference line. E. E. F.

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294. *Conductor-resistance of Cables Corrected for Leakage.* **W. J. Murphy.** (Electrician, 41. pp. 519–522, 1898.)—A simple method of arriving at Schwendler's results. The rules are:—

I. The "fall" in C.R. due to a leak is directly proportional to the square of the conductor resistance beyond the apparent position of the leak, and inversely proportional to its apparent resistance.

$$f_A = \frac{b^2}{r'}$$

II. The apparent distance of the leak from the observer is equal to the square root of the product of the fall observed by the distant station and the apparent resistance of the leak observed by himself, or $\sqrt{f_B r'}$

III. The D.R. of the cable is equal to the square of C.R. beyond the leak divided by the observed fall, or $r' = \frac{b^2}{f_A}$

IV. The resultant leak is distant from each end inversely as the square roots of the falls.

The author proposes to make weekly records of the positions of the resultant faults. Loop localisations should be obtained with the junction earthed, as the long electrification of free loops makes accuracy difficult. M. O'G.

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295. *Correction of Schaefer's Break Test for Earth Current.* **W. J. Murphy.** (Electrician, 41. pp. 716–717, 1898.)—Alluding to Schaefer (Electrician, p. 817, 1897), the coefficient of $\frac{\epsilon}{nc}$ is $\left\{ Kn-(K+n) \right\}$ a quantity which increases by 0·009 for every tenth increase of n, and the correction for earth current is equal "to the earth potential expressed in millivolts divided by the stronger of the currents in milliamperes and multiplied by 0·4 if the current ratio (n) is about 2, by 0·5 if near 3, and by 45 if about 2·5." M. O'G.

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296. *Contact Resistance.* **E. Branly.** (Comptes Rendus, 127. pp. 219–223, 1898.)—Some metals, such as copper, zinc, brass, silver, German silver, seem to offer little resistance at their surfaces, while with others (Fe, Al, Pb, Bi) the surface resistance is very great. A column of zinc or copper discs has no electric resistance; a column of aluminium, iron, or bismuth discs offers very little resistance if loaded, but a great resistance if the discs are simply allowed to fall into place, with a shock. With bismuth an electric spark passed through deprives the column of its resistance. With mixed columns similar results are obtained. These are hardly phenomena of imperfect contact, on account of the extreme and equal polish of all the discs, but it is at present difficult to classify them. A. D.

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297. *Contact Resistance.* **F. Auerbach** and **A. Meyer.** (Wied. Annalen, 66. 4. pp. 760–766, 1898.)—Two geometrically true and perfectly polished steel spheres were pressed together, and their resistance was determined when the pressure varied. The results show that the conductivity of the surface of contact varies directly as its area, but also as the integral of the pressure. The spheres used were from 4 cm. to 10 cm. in diameter, and were pressed together with forces of 100 gr. to 1000 gr. To ensure comparable results the spheres had to be exposed to the sound-vibrations from a tuning-fork before every measurement. The effect of the pressure is, of course, to flatten both spheres to an extent depending upon their elasticity. The elasticity of the steel being known, the area and the pressure at each point are calculable. The results may be utilised in inquiries regarding the nature of electric conduction. E. E. F.

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298. *Dielectric Conduction.* **W. Leick.** (Wied. Annalen, 66. 5. pp. 1107–1127, 1898.)—Guttapercha, paraffin, and sulphur in thin sheets show a higher conductivity than in thick sheets. It also varies with the current intensity, being higher in the case of stronger currents. This increase shows an after effect resembling hysteresis, since the resistances are smaller when the current is

gradually reduced than when it is first made up to the same amount. Guttapercha and paraffin show no trace of polarisation, but sulphur and collodion show it strongly. E. E. F.

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299. *Electro-Thermal Relations.* **E. Riecke.** (Wied. Annalen, 66. 3. pp. 353–389, and 4. pp. 545–581, 1898.)—The author traces the connections between thermal and electric conductivity on the basis of Weber's theory of moving ions. He obtains elaborate formulæ for the two conductivities and for the ionic velocities, which he utilises for the investigation of the Peltier and Thomson effects. He treats the occurrences at the surface separating two different metals on the assumption of a mutual diffusion of ions between them, and developes a complete theory of thermoelectricity, followed by an investigation of galvano-magnetic and thermomagnetic effects. Finally, he identifies the negative particles projected by a kathode and the supposed negative ions in the metals, and shows that they are the same in all metals. In canal rays, projected from an iron kathode, the mass of the projected particles is known to be about 56 times that of a hydrogen ion. Hence these particles are probably divalent iron ions, and if the canal rays consist of positive ions of the kathode metal, then the supposed mobile negative particles in the interior of all metals are probably nothing else but metallic ions. Zeeman's discovery leads to the assumption that the light of incandescent sodium vapour is produced by particles having a circular motion, of diameter $0{\cdot}041 \times 10^{-6}$ mm. The diameter of Ampere's current round the iron molecule is about $3{\cdot}86 \times 10^{-6}$ mm. E. E. F.

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300. *Pyroelectricity.* **W. Voigt.** (Wied. Annalen, 66. 5. pp. 1030–1060, 1898.)—The question is proposed as to whether the phenomena of pyroelectricity can be entirely reduced to those of piezoelectricity, by taking into account the changes of volume which invariably accompany changes of temperature. The author finds that about 80 per cent. of the pyroelectric charge is really piezoelectric in the case of tourmaline, but that the remainder of the charge is purely pyroelectric. The contrary result of the previous experiments made by Riecke and the author is explained by the fact that Pfaff's values for the thermal dilatation of tourmaline were not correct. On substituting correct values in the former experiments, the results are found to agree. As a general result, the author states that in crystals without a singular direction all pyroelectric charges may be reduced to piezoelectricity, but where some crystallographic direction is of a special character, there remains a residue which cannot be so explained. He proposes to restrict the term pyroelectricity to that charge produced by heating which would not be produced if

the body were kept at its original volume. A pressed tourmaline is a good source for a definite quantity of electricity. E. E. F.

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301. *Intermediate Conductors.* **J. Stark.** (Wied. Annalen, 66. 2. pp. 245–268, 1898.)—The author investigates the problem of the distribution of current intensity at the surfaces of metallic conductors in electrolytes when traversed by a current. The fundamental case considered is that of a double plate of two metals, forming a closed circuit. The current is most intense at the edges, where the path from one plate to the other through the liquid is shortest. The positive element is eaten away most rapidly there. When a current is sent through the liquid, the intensities due to it and to the double plate are superimposed. When a single plate is used, it is converted, generally speaking, into a double plate by a metallic deposit from the electrodes upon the kathode side. The author gives an elegant graphic method of representing the current densities. E. E. F.

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302. *Electrolytic Polarisation.* **H. Jahn.** Zeitschr. Phys. Chem. 26. pp. 385–429, 1898.)—The author measures the energy required to overcome the polarisation of an electrolytic cell by observing the fall in current from a battery of constant E.M.F. when the electrolytic cell is substituted for a non-polarisable cell of equal (negligible) resistance. The energy is calculated in heat units by Joule's formula, taking 0·2362 cal. as the equivalent of a watt-second. The battery, a modification of the Warren de la Rue element, placed in an ice-calorimeter, gave nearly constant values for the heat evolved in the same, per unit current, and afforded a check on the value of the E.M.F., and the calculated values for the potential of polarisation agreed within the same limits of accuracy (2–3 per cent.) with the values directly observed by Neumann and others. The temperature-coefficient is also calculated from observations at 0° and 40° C. The author also applies Planck's formula for the thermodynamical calculation of the polarisation, and comes to conclusions similar to those of Nernst and Le Blanc. B. B. T.

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303. *Flame-electrodes and Dropping-electrodes.* **E. R. v. Schweidler.** (Wien. Akad. Sitzber. 107. pp. 225–233, 1898.)—It is of interest to know (1) how far the efficiency of a collector of this type is diminished by the imperfect insulation of the system (electroscope or electrometer) connected with it and the consequent leakage; and (2) what time is in practice required for the equalisation of potentials effected by the collector (which is

theoretically an asymptotic process of infinite duration). Pellat found that impregnated strips of paper worked very slowly, water-collectors better, and flames by far the best—almost instantaneously. Exner found, under given circumstances, that the charges collected by a water-collector, and a flame were in the ratios of 0·1 : 0·5 : 1. Lord Kelvin appears to prefer his water-collector even to flames, but gives no data suitable for direct comparison. The author has endeavoured by two methods to estimate the magnitude of the conduction-current produced by such collectors when there is a given difference of potential. (I.) A conductor of known capacity C is connected with an electrometer and the collector and gives to the whole insulated system a charge whose potential V is read off on the electrometer; if the collector is placed in a space of potential V_0, the discharge-current can be obtained from the change of V by the formula—

$$i = -C \frac{dV}{dt}$$

where dV/dt is a function of $(V-V_0)$. (II.) In the second method the collector is again placed in a space of potential V_0 and is connected through a galvanometer to a point of constant potential V_1; the current corresponding to the potential difference (V_1-V_0) is then measured directly.

A. *Measurements with Flame-electrodes.*—These were first made according to Method I., using an insulated Bunsen burner. On account of the electrification of the air in the room by the gases arising from the flame, it was found that the rate of discharge was not proportional to the difference of potential. The burner was therefore mounted on a plank and pushed out some 200 cm. through the open window: although it was provided with a metallic cylinder as a protection against the wind, its action was still very irregular. The approximate magnitude of the discharge-current was 10^{-11} ampere per volt. Measurements made by the second method (using a galvanometer of 10,000 ohms resistance) gave values lying between $1-3\times10^{-11}$ ampere per volt. Candle-flames gave about half the effect of a Bunsen burner.

B. *Measurements with Dropping-electrodes.*—The water-collector used was made by removing the bottom of a flask, which was then inverted and a cork and glass tube with drawn-out end inserted in its neck. The outflowing stream of water was surrounded by a brass cylinder 20 cm. high and 10 cm. in diameter, placed so that the point at which the stream broke up lay in the centre of the cylinder. Such a collector gave a current $i = 2{\cdot}05\times10^{-11}$ ampere per volt, or had an apparent resistance of $r = \frac{1}{i} = 4{\cdot}88\times10^{-10}$ ohms. The efficiency of water-collectors could probably be increased by using fine orifices and high pressures. D. E. J.

304. *Drop of Potential in the Electric Arc.* **Mrs. Ayrton.** (Electrician 41. p. 720, 1898.)—From the + carbon to the arc the drop $V = 31{\cdot}28 + \frac{9 + 3{\cdot}1l}{A}$. From the − carbon to the arc the drop $V^1 = 7{\cdot}6 + \frac{13{\cdot}6}{A}$. As the exploring carbon influences the length and voltage of the arc an insulated exploring pencil is being made. M. O'G.

305. *Magnetic Effect of Electrolytic Currents.* **S. Sheldon** and **G. M. Downing.** (Phys. Rev. 7. pp. 122–123, 1898.)—The authors investigate the magnetic field produced by an electrolytic current in order to determine whether a current passing through an electrolyte produces magnetic influences of the same magnitude as a current of equal strength passing through a metallic conductor under the same conditions. An iron anchor ring is wound with a copper secondary and a primary of rubber tubing containing 30 per cent. solution of sulphuric acid. Then the electrolytic primary is replaced by a copper-wire primary. Using identical ampere-turns practically equal throws were obtained. S. S.

306. *Batteries for Experimental Purposes.* (Elect. World, 31. p. 716, 1898.)—A short useful account of easily constructed primary and secondary batteries suitable for supplying current for laboratory purposes. W. R. C.

307. *Efficiency of Bichromate Cells.* **W. Gratz** and **H. C. Schwecke.** (Elect. World, 32. pp. 12–13, 1898.)—This paper is an abstract of a thesis presented to Lehigh University. Curves are given showing the efficiency of a Fuller and of a Grenet cell. The ratio of theoretical consumption of zinc to the actual consumption of course increases with the current. The number of watt hours per gramme of zinc reaches a maximum for a definite current. W. R. C.

308. *Electricity direct from Carbon.* **F. Foerster.** (Chem. News, 78. pp. 180–182, 191–192, and 206–207, 1898.)—The author gives a brief account of a number of cells intended for the direct production of electricity from carbon, or its compounds. W. R. C.

309. *Thermo-Electric Battery.* **C. J. Reed.** (Amer. Instit. Elect. Engin. 15. pp. 291–325, 1898.)—The author reproduces and discusses a number of results obtained by Liebenow and

Strasser with cells containing fused alkali as the electrolyte. He claims that these results support a thermo-electric theory and not a chemical theory as supposed by their authors. In the subsequent discussion **Steinmetz** contended that the E.M.F. might be directly due to chemical action owing to the variation of chemical affinity with temperature, although indirectly due to the external heat supplied. W. R. C.

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310. *Diffusion in the Action of Accumulators.* **L. Jumau.** (Écl. Électr. 16. pp. 413–416, 1898.)—The sulphuric acid in a lead accumulator exists partly in the depth of the active material, and partly in the electrolyte, from which it passes into the material by diffusion. The amount of diffusion is proportional to the surface exposed, to the difference of concentration, and to the time; hence the capacity varies with the porosity of the active material, the density of the liquid, and the intensity of the current. The amount of acid in the active material depends, however, on the nature of the charges and discharges previously undergone, and therefore the capacity should vary with this factor also. A series of experiments show that this is the case, especially with electrolytes of low density: on repeatedly charging and discharging an element made up of a positive plate between two negatives, the current plotted against the capacity gives a closed curve, showing definite hysteresis. J. W.

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311. *Induction-Coils.* **B. Walter.** (Wied. Annalen, 66. 4. pp. 623–635, 1898.)—In extension of the author's last communication, he quotes a value found for the capacity of the secondary coil. Although it only amounts to $1{\cdot}1 \times 10^{-12}$ farad, it produces a loss of energy which should be avoided by suitable winding and a good choice of a dielectric, so as to reduce the duration of the magnetic oscillations at the break of the primary circuit. The magnetic material should combine a high susceptibility with a small hysteresis. E. E. F.

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312. *Induction-Coils.* **W. Hess.** (Wied. Annalen, 66. 5. pp. 980–998, 1898.)—The oscillations in the secondary circuit of an induction-coil are studied by the aid of the Kerr effect. A liquid condenser containing carbon bisulphide is mounted between two crossed Nicols, and every discharge is accompanied by a brightening of the field illuminated by an arc lamp, owing to the Kerr effect in the carbon bisulphide. An additional improvement is added by inserting between the condenser and the second Nicol a compressed glass plate, which produces a field of bright and dark fringes. These fringes are displaced at every discharge. A cross section of the fringes is cut out by means of a slit and

photographed by means of Klinkert's pendulum apparatus just as the discharge takes place. This has the great advantage over the older pendulum methods that the whole phenomenon is recorded in its entirety, although it suffers under the disadvantage that the fringes are never very sharp, and the curves always a little blurred. The author reproduces plates showing some of the photographs obtained. They show multiple oscillations in circuits with high inductances, and simple displacements in circuits of high resistance. E. E. F.

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313. *String Interrupter.* **L. Arons.** (Wied. Annalen, 66. 5. pp. 1177–1179, 1898.)—The author's new type of string interrupter does not require an electromagnet, and is therefore specially adapted to high oscillations which would be injuriously affected by high inductances in the circuit. A copper wire is stretched between two binding-screws joined by a conductor. In the centre of the wire is mounted a thin platinum wire which dips into mercury under water, and makes contact for a circuit. A horseshoe magnet is fixed above the wire, so that it attracts both portions of the wire when the current passes. The attraction interrupts the current and sets the wire vibrating in its own natural period. E. E. F.

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314. *Temperature Coefficients of the Standards for the* 1897 *ohm.* **M. Solomon.** (Electrician, 41. pp. 717–719, 1898.)—Explains the thermostat used for varying the temperature of one standard 10-ohm coil while the other was kept constant. Four sources of error are considered. The tests are tabulated and Mr. Glazebrook's 1897 test confirmed. M. O'G.

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315. *Absolute Electrometer.* **A. Perot** and **C. Fabry.** (Journ. de Physique, 7. pp. 317–335, 1898.)—The authors give an account of their absolute electrometer which has already received frequent notice (see Phys. Soc. Abstracts, No. 494, 1897, and Science Abstracts (1898) Nos. 23, 233, and 485). W. R. C.

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316. *Exploring the Potential Round Commutators.* **G. D. Shepardson.** (Amer. Electn. 10. pp. 453–454, 1898.)—The author describes a simple and accurate device for exploring the potential round commutators which is in use in the electrical laboratory of the University of Minnesota. The device consists of a strip of hard fibre 1/16 inch thick, 1/4 or 3/8 inch wide, and long enough to reach a little more than half-way round the commutator. A row of small holes is drilled in the fibre at distances

apart each equal to the width of one commutator bar, together with the mica insulation. A larger hole is drilled at each end of the strip, into which a hard cord or wire is fastened. A thin coating of graphite is then smeared over the inside of the ring for purposes of lubrication. The strip is fixed on the commutator, and the potential round may be explored either by the single or double brush method, the end of the wire being held against the commutator through the holes. W. G. R.

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317. *Alternate-Current Problems.* **T. R. Lyle.** (Electrician, 41. pp. 816–818; 42. pp. 72–74 and 148–151, 1898.)—The author introduces symbols for the various operations by which, in the ordinary clock diagram methods, we pass from the current to the E.M.F. vector, and *vice versâ*. Thus, if C stand for the current vector in a clock diagram, E for the E.M.F. vector, and if R and L denote the resistance and inductance of the circuit respectively, the author writes the vector-equation

$$E = r\,C,$$

where r is an *operator*, and denotes the operation by which the current-vector is transformed into that of E.M.F. If i be now used to denote the operation of turning a given vector through a right angle ($i^2 = -1$), and $e^{i\phi}$ that of turning it through an angle ϕ in the positive direction, then, putting $I = \sqrt{R^2 + p^2 L^2}$, and $\tan\phi = Lp/R$, r may be variously written as

$$R + ip\,L, \text{ or } I\,(\cos\phi + i\sin\phi), \text{ or } I\,e^{i\phi}$$

Further, if we write $\frac{1}{r}\,E = C$, $\frac{1}{r}$ may be shown to be correctly represented by

$$\frac{1}{R + ip\,L}, \text{ or } \frac{R - ip\,L}{I^2}, \text{ or } \frac{\cos\phi - i\sin\phi}{I}, \text{ or } \frac{e^{-i\phi}}{I}.$$

The operator r follows the ordinary laws of algebra, and it is at once evident that by its use the vector equations connecting the various vectors in a clock diagram are considerably simplified. The author applies this elegant notation to the solution of a number of problems, by which the simplicity and power of the method are strikingly exemplified. A. H.

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318. *Energy of the Magnetic Field.* **H. Pellat.** (Comptes Rendus, 127. pp. 507–510, 1898.)—This refers to a former paper by the same writer (C. R. 125. p. 699, 1897), in which he showed that the ordinary expression for the energy of an electric system

requires to be rectified by taking account of the heat withdrawn or introduced during the charge. In the present paper the same thing is shown for a magnetic system. A system of closed currents is supposed to increase in intensity from zero to I_1 I_2. The current in the first circuit at any instant is $\frac{i_1}{I_1}=z$; in the second $\frac{i_2}{I_2}=z$, &c. If dQ be the quantity of heat supplied from without, during the increase dz of z, it is assumed that

$$dQ=cdT+bdz$$

where T is absolute temperature. And it is shown that b is not zero. S. H. B.

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319. *Mechanical Illustration of Magnetic Phenomena.* **C. Weyher.** (Comptes Rendus, 127. pp. 811–813, 1898.)—A magnet is represented by a wooden cylinder provided with oblique vanes, and capable of being set in rotation. It is suspended in such a manner that while rotating it is capable of being deflected like a pendulum. When rotating, it sucks in air (or water, if placed in a vessel containing that liquid) at either end, and ejects it at the middle. If two such cylinders be set rotating, the phenomena of magnetic attraction and repulsion may be reproduced. A. H.

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320. *Magnetic Properties of Nickel Steels.* **E. Dumont.** (Écl. Électr. 16. pp. 292–300, 1898.)—An account of investigations supplementing those of Guillaume, already noticed in Abstract No. 1257 (1898). J. J. S.

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321. *Deformation of Iron in a Magnetic Field.* **E. Rhoads.** (Phys. Rev. 7. pp. 65–82, 1898.)—Strips of iron are cut from a sheet of transformer iron, some at right angles, others parallel to the length. The latter show greater elongations in a magnetic field, and indicate that the elongations in a given direction are influenced by the fibrous structure. A. Gs.

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322. *Magnetisation by Alternate Currents.* **M. Wien.** (Wied. Annalen, 66. 5. pp. 859–953, 1898.)—Small toroids were made of thin iron wire, and provided with a magnetising coil. Their inductance and effective resistance were determined after Maxwell's method by the optical telephone. The magnetising current was provided by an alternate-current siren, and

had frequencies of 128, 256, or 520 per second. It was made very approximately sinusoidal by resonance. It was found that these currents not only produce an induction of the same period, but also of higher periods, the latter becoming more marked as saturation is approached. The loss of energy is enhanced by these higher periods and by the heat generated by them. It is found that separate insulation of the constituents of the core is ineffective as a remedy. Permeability and induction are always smaller in the sinusoidal than in the constant field, but the difference is small in the neighbourhood of the saturation point. It is larger, on the other hand, when the frequency is high and the iron wire is soft and thick. As a general result, it appears that induction cannot keep up with very rapid oscillations of the magnetising force. In such fields iron behaves as if it were harder than it is in a constant field. The hysteresis loops are broader and shorter. E. E. F.

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323. *Magnetisation of Crystals.* **A. Lutteroth.** (Wied. Annalen, 66. 5. pp. 1081–1106, 1898.)—A large number of hydrated sulphates and alums were examined by Wiedemann's method. They belonged to the monoclinic and rhombic systems, and some were paramagnetic and others diamagnetic. In all of them the ratio of the magnetisations along any two axes changed with the temperature in a linear manner. In any group of crystals belonging to the same isomorphous series the temperature coefficients along the three axes are in a constant proportion. For the sulphates of nickel, zinc, and cobalt the temperature coefficient is positive when the axis of greatest magnetisation is made the axis of suspension, but negative when the intermediate axis of magnetisation is chosen. This result is opposed to that of Faraday. The author also shows that the orientation of a crystal in a homogeneous magnetic field may be fully explained on the assumption of molecular magnets capable of turning.
E. E. F.

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324. *Magnetic Susceptibilities.* **J. Koenigsberger.** (Wied. Annalen, 66. 4. pp. 698–734, 1898.)—The author has confirmed H. du Bois's theorem according to which the susceptibility of ferric chloride and other solutions is constant in various fields, so long as they contain no free iron. He finds that bodies with the smallest atomic volume are, generally speaking, the most strongly paramagnetic. The susceptibility of water is found consistently to be $-0{\cdot}8\times10^{-6}$ at 20° in air. E. E. F.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

325. *Etherion—a New Gas.* **C. F. Brush.** (Science, 8. pp. 485–494, 1898.)—The author from the high heat conducting capacity of high vacua believes that an occluded gas of insignificant molecular weight but of very high specific heat and molecular velocity exists in glass and other solids. Alterations in pressure were noticed when phosphorus pentoxide and soda-lime were present in the vacua; the author concluding that the gas is reabsorbed by them. (See also Phil. Mag. Jan. 1898.)

S. R.

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326. *Process of Crystallisation.* **G. Tammann.** (Wied. Annalen, 66. 3. pp. 473–498, 1898.)—The current opinion which assumes the possibility of a continuous transition from the liquid to the crystallised state and *vice versâ* is, according to the author, inconsistent with theory and with actual observations. The only satisfactory definition of the solid state rests upon the assumption of a discontinuity between the solid and liquid states. Ostwald supposes that the crystallisation curve may proceed along a Thomson-van-der-Waals isothermal. But this assumption implies the existence of four volumes at the same pressure. Heydweiller's observation of an alleged continuous transition of menthol from the liquid to the crystallised state, with formation of a peculiarly transparent variety of the crystals, is probably due to some impurity in the menthol used. E. E. F.

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327. *Gelatinisation of Starch.* **H. Rodewald.** (Zeitschr. Phys Chem. 24. pp. 193–218, 1897.)—By determining the heat evolved when water is added to starch, the author finds that the heat of gelatinisation is a function of the amount of water absorbed. The alteration in volume is similarly a function of the water content. He shows that the specific volume of starch $X_0 = 0{\cdot}67273$ and gives tables showing the volume contraction with varying amounts of water. From the vapour pressure changes he calculates the molecular weight of gelatinised starch as 4374 or $(C_6H_{10}O_5)_{27}$. He also shows that the coefficient of expansion is a function of the water content. S. R.

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328. *Conductivity of Solutions of Praseodymium and Neodymium Sulphates.* **H. C. Jones** and **H. M. Reese.** (Chem. News, 78. pp. 102–103, 1898.)—The following numbers are obtained;

v is the volume of solution in litres, containing 1 gram molecule of the salt, and μ the molecular conductivity :—

Praseodymium Sulphate (Mol. weight = 569·1).		Neodymium Sulphate (Mol. weight = 575·4).	
v.	μ.	v.	μ.
14·71	98·33	...	...
29·42	117·43	25·33	115·03
58·84	141·42	50·65	137·65
117·68	169·47	101·31	166·35
294·2	217·83	202·61	197·91
588·4	262·65	506·5	255·43
1176·8	317·10	1013·0	303·45
1471·0	331·43	2026·0	366·0
2942·0	403·37	2532·6	382·9
5884·0	482·61	5065·2	462·5

The units and temperature employed are not stated. (Cf. American Chem. Journ. 20. p. 345.) T. E.

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329. *Electrolytic Solution of Noble Metals.* **M. Margules.** (Wied. Annalen, 66. 3. pp. 540–543, 1898.)—The author describes a simplified apparatus for the electric solution of gold and platinum. A revolving commutator alternately sends the current through the cell, and short-circuits it. Another device consists of a hammer interrupter, to which a separate contact piece is attached. At every oscillation, the contact piece short-circuits the cell, or sends a current through it in opposition to the first current. Under these circumstances, platinum dissolves at the electrode, which is the anode for the stronger current or the greater electric quantity. The behaviour of gold is very different from that of platinum. The latter cannot be dissolved even in hydrochloric acid by means of a constant current, whereas gold is easily dissolved in hydrochloric, strong nitric, or sulphuric acid, under the influence of a constant current. E. E. F.

330. *Calculation of Electrolytic Conductivity.* **F. C. McKay.** (Elektrochem. Ztschr. 5. pp. 113–119, 1898.)—An elaborate series of measurements of the conductivities of barium and sodium chlorides made by Kohlrausch's method, with special precautions as to purity and accuracy of analysis, show that MacGregor's graphic method of calculating the conductivity of a mixed solution is valid in this case up to a concentration of 2 gram-mols. per litre. J. W.

331. *Mobility of Ions.* **F. Kohlrausch.** (Wied. Annalen, 66. 5. pp. 785–825, 1898.)—The author attempts to find some rule and tables by which the conductivity of a solution of one or more salts can be found from a knowledge of the mobilities of their ions and their respective concentrations. He finds that for solutions up to deci-normal strength such tables of mobilities can be found, and that as long as the ions are monovalent, or only one combination is divalent, the conductivities of any solutions containing one or two salts can be calculated. An important observation made is that the same ion possesses the same mobility in different electrolytes; also, the decrease of mobility with increasing concentration is approximately the same for all ions. The mobilities at infinite dilution are:—

Kations: K 65·3, Na 44·4, Li 35·5, Rb 67·3, NH_4 64·2, Ag 55·7, and H 318.
Anions: Cl 65·9, I 66·7, F 46·1, NO_3 60·8, ClO_3 55·3, $C_2H_3O_2$ 34·5, HO 174.

The decrease of mobility from these values at infinite dilution to the values at any given concentration is directly proportional to the linear concentration, *i.e.*, the cube root of the volume concentration. The much more mobile ions H and HO show a much stronger decrease of mobility. So do the combinations of divalent ions when mixed with monovalent salts.

E. E. F.

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332. *Alleged Decomposition of Sulphur (Bythium).* **H. Alexander.** (Zeitschr. Elektrochem. 5. pp. 93–95, 1898.)—The alleged new element *bythium*, stated by Gross to result from the decomposition of sulphur in the electrolysis of a fused mixture of silver chloride and sulphide, is non-existent, as the product of the electrolysis is proved by elaborate chemical analysis to contain the same elements, and in the same quantity, as the original substances. J. W.

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333. *Electrolytic Preparation of β-Phenylhydroxylamine.* **F. Haber.** (Zeitschr. Elektrochem. 5. pp. 77–78, 1898.)—Describes a special form of cell for the electrolytic reduction of this substance from nitrobenzene. Orthotolylhydroxylamine is prepared in the same way from orthonitrotoluene. J. W.

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334. *Electrolytic Formation of Azo- and Hydrazo-Compounds.* **K. Elbs** and **O. Kopp.** (Zeitschr. Elektrochem. 5. pp. 108–113, 1898.)—Various nitro-compounds are electrolysed in presence of sodium acetate, in dilute alcoholic solution, and the products examined and identified. Mainly of chemical interest.

J. W.

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335. *Electrolytic Production of Beryllium and its Alloys.* **P. Lebeau.** (Elektrochem. Ztschr. 5. pp. 111–113, 1898.)—The simple halogen salts of beryllium are non-conductors, but the double alkali fluorides, such as beryllium potassium fluoride, readily melt to conducting liquids which yield beryllium on electrolysis. The kathode is a nickel crucible, the anode a carbon rod; the current is 20 amperes at 80 volts, and the metal is deposited in brilliant hexagonal crystals of sp. gr. 1·73, containing 99·7 per cent. of beryllium. Alloys are prepared electrolytically by substituting for the nickel crucible the desired metal melted in a hollow carbon kathode; they are also formed by reducing the mixed oxides of beryllium and the metal with carbon in an electric furnace carrying 900 amperes at 45 volts. The appearance of copper is quite changed by 0·5 per cent. beryllium, and with 21·3 per cent. the alloy is golden yellow, and very sonorous.

J. W.

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336. *Electrolytic Reduction of m-Nitro-p-toluidine.* **K. Elbs** and **B. Schwarz.** (Zeitschr. Elektrochem. 5. pp. 113–115, 1898.)—An account, from a chemical point of view, of the products of electrolysis of solutions of the above substance.

J. W.

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337. *Electrolytic Production of Metallic Oxides.* **Otto** and **H. Strecker.** (Electrician, 41. pp. 17–18, 1898.)—The economical production of metallic oxides by electrolysis depends on a proper choice of electrodes and on the composition and density of the electrolyte. The E.M.F. required may often be reduced by using as the kathode a metal other than that which forms the anode. Tables are given showing the requisite E.M.F. for any pair of metals, when a solution of sodium chloride (26 per cent.) or of sodium chlorate (15 per cent.) is used as the electrolyte. When the latter consists of a solution of two salts, one of which acts as a solvent and the other as a precipitant, the former should be present in such a proportion as to yield a solution of maximum conductivity, whilst the quantity of the latter to be employed is calculated according to the electro-chemical equivalents and the reaction which it is desired to effect. N. L.

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338. *Electrolytic Determination of Uranium and Cadmium.* **E. F. Smith** and **D. L. Wallace.** (Chem. News, 78. p. 58, 1898.)—Heidenreich has used the authors' methods for the electrolytic determination of the above metals, and has failed to obtain satisfactory results. In order to confirm their earlier results, the authors have repeated their experiments, and give figures to show that under the conditions recommended their

methods are entirely satisfactory. For uranium they use a solution of the acetate, and for cadmium they employ a solution containing sodium phosphate and free phosphoric acid. The article gives details of the experiments, and the results of three determinations of known amounts of each of the metals.

J. B. C. K.

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339. *Deposition of Cadmium and its Alloys.* **S. Cowper-Coles.** (Elect. Rev. 43. pp. 587–588, 1898.)—An article giving details of the solutions recommended by Smee, Woolrich and Russell, and Bertrand, for obtaining deposits of metallic cadmium. Details are also given of the method to be used for obtaining deposits of cadmium-silver alloys. These are stated to be coming into use for plating parts of bicycles and domestic articles. A cyanide solution of the two metals is recommended, containing 3–4 oz. metal in solution per gallon, and from 8 to 25 dwts. silver per gallon. A low current density must be employed. If stronger solutions be used, the proportion of silver in the deposited alloy will be increased. Trials have shown that this alloy is superior to nickel as a coating for iron exposed to atmospheric influences.

J. B. C. K.

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340. *Deposition of Chromium.* **S. Cowper-Coles.** (Elect. Rev. 43. pp. 477–478, 1898.)—The author describes some of the characteristics of chromium, and then goes on to describe Professor Hittorf's experiments on the behaviour of chromium in dilute acid solutions. A brief description is also given of Herr Eskmann's process for preparing chromium in the electric furnace.

The production of chromium by reducing chromium oxide with aluminium in a fine state of division is mentioned; the paper concludes by giving the price of chromium and its salts, and a brief description of some experiments made with the electro-deposition of chromium, and a table is given of the comparative hardness of electro-deposited chromium as compared with other metals.

AUTHOR.

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341. *Electrolysis of Alkali-metal Chlorides.* **H. Wohlwill.** (Zeitschr. Elektrochem. 5. pp. 52–76, 1898.)—A detailed account of an investigation carried out by the author, too lengthy for full abstraction. The object of the author was to discover whether the formation of hypochlorites and of chlorates during the electrolysis of aqueous solution of sodium or potassium chloride, was due, as generally supposed, to secondary chemical reactions, or as some of the latest investigations had indicated, to primary electrolytic, or "ionic," reactions. He discusses the published literature of the subject, and refers to the previous work of Nernst and

Glaser, of Oettel, and of Haber, in relation to this subject. After describing his method of investigation and the apparatus used, he gives a detailed account of the results obtained in the numerous electrolytic decompositions of chloride solutions with gradually increasing E.M.F. at the cell electrodes, the results being given in numerous "curve" diagrams.

The whole investigation led him to the following conclusions:—

(1) A formation of hypochlorite occurs, when an E.M.F. of only 1·2 volts is attained, between a platinum anode and hydrogen kathode. The formation is practically quantitative, and is probably represented by the following ionic equation:—

$$\overline{Cl} + \overline{O} \ (+ \ +) = \overline{ClO}$$

(2) A formation of hypochlorite in much larger quantity occurs when the E.M.F. rises to 2·1 volts or above this limit. This is attributed by the author to the secondary chemical reaction of the separated chlorine with the alkali formed at the kathode.

(3) The formation of chlorate is explained by the author as due to the + charges of electricity, communicated to the ions at the anode. The ionic reaction is, however, not between $\overline{Cl}$ and $\overline{OH}$ ions, but between previously formed $\overline{ClO}$, and $\overline{OH}$ ions, and is probably represented by the following equation:—

$$2 \ \overline{ClO} + \overline{OH} \ (+ \ +) = H \, ClO_3 + \overline{Cl}$$

J. B. C. K.

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342. *Electrolytic Galvanising.* **S. Cowper-Coles.** (Elect. Engin. 22. pp. 466–467, 1898.)—This is an abstract of a paper read before the Society of Engineers. The first part of the paper, dealing with the causes of corrosion and the old method of hot galvanising, are passed over in a few words, but the portion which deals with the question of the best solutions from which to obtain coherent bright zinc deposits upon iron and steel, is given verbatim. The author describes and comments on Elsner's, on Siemens and Halske's and on other methods. He also refers to Kiliani's researches into the importance of considering the E.M.F. and current density for obtaining firm deposits. A total analysis of a typical sample of spongy zinc is given, which may be of use. J. L. F. V.

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343. *St. Michael Electrolytic Chlorate Works.* **J. B. C. Kershaw.** (Elect. Rev. 43. p. 791, 1898.)—The author describes important developments which have taken place since 1890 in the South-Eastern Provinces of France (Rhone valley) in the utilisation of water power for electrochemical processes. Over 10,000 H.P. are already available. An account of the installa-

tion at St. Michael below Modane on the Arc, a tributary of the Rhone, is here given. At the works of the Société d'Electrochimie 3000–4000 H.P. are utilised for the manufacture of sodium and potassium-chlorate by the Gall and Montlaur process. An underground channel $1\frac{1}{4}$ miles in length conveys the water 230 feet above the works and operates twelve 200-H.P. and four 400-H.P. turbines from two pipe lines 330 yards long, 47″ diameter, capable of delivering 1,760 gallons water per second. Thury dynamos running at 300 revs. generating a current of 1000 or 500 amperes at 200 volts, or 2000 kw. in all, are used. The principle for the production of chlorates is that already patented by C. Watt in 1837, *i.e.*, the electrolysis of an alkaline chloride between insoluble anodes at a moderately high temperature. A series of equations are given explaining reactions involved. In practice, rectangular lead-lined vats of 11,000 gallons capacity are used, fitted with anodes of a platinum-iridium alloy and kathodes of ferro-nickel, the latter being covered by asbestos cloth in order to remove the hydrogen generated at the surface. Diaphragms were originally used, but are believed to have been abandoned. A current density of 465 amperes is employed, and the solution thereby kept at a temperature of 45° C., no external heat being required. The chlorate is separated by crystallisation and the solution brought up to strength by the addition of fresh chloride. The presence of metallic oxides in the vat acts deleteriously, resulting in the formation KCl and O from KClO. The Société d'Electrochimie possess another works at Vallorbes with 3000 H.P. The total output of the two works amounts to about 1800 tons per annum. The author gives particulars as to cost of production, and concludes that there is not a large margin of profit. O. J. S.

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344. *Dumoulin Copper-Depositing Process.* **J. B. C. Kershaw.** (Elect. Rev. 43. pp. 561–562, 1898.)—An illustrated description of the writer's visit to the works of the Electrical Copper Company at Widnes. The company owns the Dumoulin Patents. The plant comprises 5 Peach Engines, each of 160 I.H.P., direct coupled to 5 Crompton continuous current dynamos. These deliver 1300 amperes at 75 volts = 97·5 kw. each. The depositing vats are 30 in number, and are shallow lead-lined troughs, each provided with a revolving mandrel 12 ft. long × 16″ in diameter. This mandrel is half immersed in the electrolyte, and functions as kathode. The electrolyte contains 7 per cent. free acid, and 40 per cent. copper sulphate, and is cooled and filtered after each passage through the depositing vats. The deposit of copper upon the mandrel is rendered coherent and dense by means of strips of sheepskin, which hang over, and lightly press upon, the upper surface of the mandrel. Thick plates of raw copper, bent into semicircular form, are used as anodes. Under normal working conditions 10 hours suffice to

deposit 44 lb. copper upon one mandrel, and to produce a tube of deposited copper, weighing 14 oz. to the sq. foot. The current density employed varies between 35 and 40 amperes per sq. foot; and the E.M.F. required is 1·6 volts at first, rising as the anodes become eaten away. The large tubes of copper made at Widnes are cut longitudinally, and converted into sheets having a superficial area of 48 sq. feet. The present capacity of the plant is equal to 60 sheets per day, but it is about to be increased by the erection of depositing vats for the production of boiler-tubes. Recent tests of the deposited copper show a tensile strength of 18½–24 tons, and an elongation of 28–30 per cent. AUTHOR.

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345. *Cowper-Coles Process for Treatment of Refractory Ores.* (Elect. Rev. 43. pp. 788–789, 1898.)—An illustrated description of this process as carried out at Hayle, in Cornwall. The ore is crushed, roasted, and leached in rectangular vats with a sulphuric acid solution—in order to extract the zinc. The vats hold from 1½–2 tons of ore; the finer portions of the ore are leached separately in a revolving barrel. The zinc is electro-deposited from the resultant zinc sulphate solution as zinc sponge upon a revolving disc kathode.

It is proposed to use this product in place of zinc dust. It contains 54·8 per cent. zinc, 12·55 per cent. combined oxygen, 10·55 per cent. sulphuric anhydride, 13·35 per cent. moisture and organic matter, 1·05 per cent. silica, 1·20 per cent. alumina, and smaller amounts of other impurities. The lead is extracted from the ore remaining in the leaching vats by a solution of sodium hydrate. The resultant sodium plumbate solution is either used in the electro-depositing vats, or is employed for production of white lead. In the former case, the revolving disc kathodes are used as before, to receive the deposit. Silver, if present, is extracted from the ore by dilute cyanide solution, and is recovered by electro-deposition upon silver kathodes. No details of efficiency or cost are given in the article. J. B. C. K.

GENERAL ELECTRICAL ENGINEERING.

346. *Preventing Magnetic Leakage from Dynamos.* **J. F. Kelly.** (Elect. World, 32. p. 161, 1898.)—This device forms the subject matter of U.S. patent No. 608133, and consists in arranging an electromagnet coil on the shaft connecting the crank-shaft of a direct-coupled engine to the inductor of the alternator driven thereby. This coil produces a magneto-motive force in the shaft which prevents a stray field being set up in the engine, this stray field being liable to cause binding and heating. C. K. F.

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347. *Detecting Approach of Objects at Sea.* **H. Herberts.** (Elect. Engin. N.Y., 26. pp. 97–99, 1898.)—This proposed apparatus comprises two thermopiles arranged on a ship and caused to slowly rotate about a vertical axis. These thermopiles are arranged with their collecting cones facing opposite sides, and are each connected through sliding contacts with a d'Arsonval galvanometer; the moving coils of these galvanometers bear aluminium arms which, when the coil is deflected, complete one or other of two electric-bell circuits, according to the direction in which the current flows, that is to say, when the thermopile cone is directed towards a warm body, a vessel for example, one bell will give a short ring, whilst when it is directed towards a cold object, an iceberg for example, the other bell will give a short ring. The direction of the particular object is determined by means of an electrically operated pointer which rotates synchronously with the thermopiles. By watching the instantaneous position of the revolving pointer at the moment the bell rings, and simultaneously cutting out one of the thermopiles by a switch, an approximate knowledge of the direction of the object can be obtained. By introducing resistance into the thermopile circuits, the aluminium arm can be made to complete the bell-circuit only at the instant the maximum current is being produced, and thus the exact direction determined. By the increasing or diminishing action of the thermopiles, it can be determined whether the object is approaching or receding. Further details and diagrams of the apparatus and modifications thereof are given in the original paper. C. K. F

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348. *Westinghouse Electric Turn-table "Donkey."* (Elect. Engin. N.Y., 26. p. 185, 1898.)—This round-house "donkey" comprises a series reversible 10 H.P. motor mounted within a heavy cast-iron frame having a traction wheel which rests upon the rail of the turn-table pit and to which the power is transmitted through double reduction gears. The donkey-frame is con-

nected by drawbar and pin to one end of the turn-table at the side, sufficient traction for the driving-wheel being secured by the weight of the machine, 3,700 pounds. It may be moved in either direction, and its speed varied by means of a switch and rheostat controlled by a single lever. No changes are required in the turn-table in order to instal the "donkey." With turn-table light the donkey will make a complete revolution in 30 secs., whilst with a 10-wheel locomotive and tender, weighing 100 tons, a complete revolution is made in 45 secs. From actual tests it is stated that the power consumed is the equivalent of one-half H.P. hour. Assuming 6 pounds of coal per H.P. hour, with coal at $2 per ton, the cost of turning each locomotive would be 3 10 cent. C. K. F.

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349. *Boiler-Feeding by Injectors.* **J. Whitcher.** (Elect. Rev. 43. pp. 303–304, 1898.)—The author discusses boiler feeding by injectors and pumps. If a boiler at 140 lbs. working pressure be fed by a pump of 50 per cent. efficiency through a heater raising the temperature of the feed from 100° to 200° F., 1 lb. of steam will pump 100 lbs. of water, and the heat thrown away in the pump exhaust is 1,120 B.T.U., whereas the heat abstracted from the exhaust heater is 10,000 B.T.U. An injector will save the former quantity and reject the latter. Therefore it is bad policy to use an injector where feed heating is possible, and bad policy to use a pump unless in conjunction with a feed heater. Apart from the question of feed heating, the injector merits preference above all other appliances for boiler feeding. Better opinions regarding it would be obtained if two injectors of equal size and combined capacity, just slightly greater than the maximum rate of feed were mounted independently, so that either could be easily dismantled during working hours. A. S.

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350. *Mechanical Draft.* **W. B. Snow.** (Amer. Electn. 10. pp. 244–249, 1898.)—A paper discussing the advantages of mechanical draft from the points of view of increased boiler efficiency, possibility of increasing the power of boilers, and reduction of capital and working expenses. The paper is illustrated by numerous diagrams and examples from practice. A. S.

GENERATORS, MOTORS, AND TRANSFORMERS.

351. *Modern Brush-Holders.* (Elect. World, 32. pp. 87–91, 1898.)—The paper contains an interesting and fully illustrated description of the typical forms of brush-holders used in connection with the machines exhibited at the recent New York Electrical Show. Carbon brushes are used in every case, and in most holders are arranged to bear on the commutator in a radial direction (the tangent contact brush seems to have quite disappeared). It is impossible to adequately abstract the paper without a large number of sketches.

[An illustrated abstract appeared in *The Electrician*, 41. pp. 616–618, 1898.] A. H.

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352. *Drum Armature Windings.* **A. L. Rice.** (Amer. Electn. 10. pp. 363–365 and 419–420, 1898.)—The author discusses the winding of slotted multipolar drum armatures with two or four layers, with either single wire or cable. In a four-pole armature with four layers, one conductor from each layer must be wound into a coil, the pitch must be odd, and the front and back pitch different. The whole of the bottom layer is wound first, then the whole of the next layer, and so on. In order to wind a four-layer armature into a two-circuit machine it is necessary to use a combination of lap and wave winding, which has been called Wenström winding; it follows no expressible law, but must be worked out for each case. R. B. R.

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353. *Commutator Segments.* **F. X. Cicott.** (Railway World, 7. pp. 81–84, 1898.)—The author draws attention to the disadvantages of cast copper segments, and describes the process of drop-forging commutator segments. A cylindrical rod of copper of the size bar required is heated to a malleable state in an oil furnace producing a uniform heat, and while in that state the rod is bent to form, then passed for the action of dies in the drop-press and stamped, which produces an unfinished segment of the designed shape. This is treated with acid to remove the oxide. The rough edges are trimmed, and the bars cold-dropped to bring them to the required gauge. Hard drawn copper segments are also used in America. The General Electric Co. of Schenectady use hard-drawn only. The paper contains a table of angles of segments for commutators of 4 to 150 parts. The author concludes by remarking that the use of wrought copper should be seriously considered by the European manufacturers. R. B. R.

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354. *Armature Winding for Multiphase Generators.* (Elekt. Runds, 15. pp. 264–265, 1898.)—The new method of winding used by the Maschinenfabrik Oerlikon for multiphase work is diagrammatically illustrated. It has the advantage of giving a symmetrical curve of E.M.F. without involving the use of two sizes of spool. E. H. C.-H.

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355. *Induction Motors.* **A. E. Wiener.** (Amer. Electn. 10. pp. 372–373, 1898.)—This is the third of a series of articles, and deals exclusively with the stator windings of di-phase and tri-phrase induction motors, both drum and ring windings being considered. W. G. R.

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356. *Rotary Converters.* **P. Janet.** (Comptes Rendus, 127. pp. 351–352, 1898.)—The author examines the working of a single-phase rotary converter on the assumption of 100 per cent. efficiency, and gives the following results :—

1. For a given excitation there exists only one alternating pressure E_a for which the pressure E_c on the continuous current side is given by $E_c = \sqrt{2}\, E_a$.

2. If without altering the excitation, E_a is varied, the ratio $\sqrt{2}$ no longer holds between the two pressures. The pressure E_c is then of an undulating nature and is compounded of a uniform pressure c and an alternating one having twice the frequency of the applied pressure.

3. If the applied alternating potential difference is kept constant while the excitation is varied, the pressure at the direct current side is undulating. If the excitation increases, the uniform pressure c increases but always remains less than E_c. W. G. R.

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357. *Transformer Regulation.* **F. Bedell.** (Elect. World, 32. pp. 364-365, 1898.)—The author gives working formulæ for determining the regulation drop in lighting and power transformers.

The secondary load in lighting transformers is non-inductive, and the effective reactance drop is

$$\frac{x^2 + 2\,x\,i_\mu}{200}$$

where x is the per cent. reactance drop and i_μ the per cent exciting current, magnetising component. The secondary load in power transformers is inductive, and the drop is now

$$c \cos \delta + x \sin \delta$$

where c is the per cent. resistance and $\cos \delta$ the power factor.

W. G. R.

POWER DISTRIBUTION, TRACTION, AND LIGHTING.

358. *Cost of Steam and Water Power.* **W. O. Webber.** (Eng. Mag. 15. pp. 922–927, 1898.)—The author estimates the present cost of operating a 1,000 H.P. steam plant as follows :—

	Dollars per H.P. per annum.
Interest on capital, depreciation, repairs, &c.....	6·55
Coal (1·4 lbs. per I.H.P. hour, at 3·85 dols. per ton)...	7·41
Wages (two engineers, two stokers).....	3·08
Oil, waste, &c.	·80
Total.....	17·84

i.e., £3 14s. 4d. per H.P. per annum.

The actual return from the best plant known to the author gives a total cost of 11·64 dollars per H.P. per annum, the coal costing 1·76 dollars per ton. The plant consists of a vertical, cross-compound, condensing engine by the E. P. Allis Company, the load averaging 1,950 H.P. The steam pressure is 155 lbs. per square inch. The boilers are of the Heine water-tube pattern ; an exhaust steam heater and a Green economiser are used.

The actual cost of a small water-power plant consisting of three wheels giving a maximum of 510 H.P. is 5·56 dollars (£1 3s. 3d.) per H.P. per annum, the average power being taken at 315 H.P.

A. S.

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359. *Electrical Transmission of Power.* **P. Janet.** (Écl. Électr. 16. pp. 547–551, 1898 ; also Rev. gen. des Sciences pures et appliqués, 9. pp. 638–646, 1898.)—This paper gives several rules to be used in designing a transmission plant, and a careful analysis of comparative costs of several water and steam-power installations.

M. G. W.

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360. *Unequal Loading in Polyphase Distribution.* **V. Spagnuolo.** (N. Cimento, 7. pp. 293–319, 1898.)—This paper treats of the variations in pressure produced in three-phase distribution when the loads on the three circuits are unequal, in respect to resistance, self-induction, or capacity. The star system only is considered, the variations in pressure being determined between each pair of the three conductors, and also between each conductor and a central neutral wire. The matter is treated theoretically at great length, and the results of some experiments are given, made on a Gramme continuous current machine adapted for three-phase currents. The load was varied by introducing resistance or self-induction. The following conclusions are arrived at: If

1, 2, 3 be the three circuits taken in the sense of the rotating field, and V_1 V_2 V_3 the respective pressures, if the resistance in 2 be increased, V_2 is largest, V_1 is smallest, and V_3 slightly more than V_1. The same effects are produced in the difference of potential between each conductor and the neutral wire, but the variations are less marked. With equal resistances, if self-induction be introduced in 2, V_2 is largest, V_3 is smallest, and V_1 slightly more than V_3. Considering the pressures to the neutral wire, V_3 is smallest, and V_1 and V_2 are equal. G. H. Ba.

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361. *Llandudno Electric Supply Works.* (Electrician, 42. pp. 11–14, 1898.)—The paper contains a full description of the works, the principal feature of interest being the arrangement for firing two of the boilers from Beaman and Dea's refuse destructors. M. G. W.

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362. *Boston Electric Lighting Station.* (Elect. World, 32. pp. 523–527, 1898.)—This is a good account of the Boston Electric Light Station which has from an early commencement been conducted on alternating current lines, and well illustrates the advantage of using synchronous motors. There are no less than twenty 150 kilowatt synchronous motors each coupled to two 160-light Brush multicircuit arc machines. The switchboard is remarkable for the use of aluminium bus bars, mounted on a separate marble board. W. G. R.

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363. *Three-Phase Installation at the Bristol Waggon and Carriage Works.* **W. Geipel.** (Elect. Rev. 43. pp. 427–429, 1898.)—This is a paper read before the British Association, and deals principally with the saving of power effected by using electric motors for driving machines instead of a multiplicity of steam engines in a works of wide area. At the Bristol Waggon Works five Lancashire boilers have been necessary for driving the engines; with electric power plant one Lancashire boiler will suffice, and the saving of coal is estimated at 37 tons per week. The three-phase system has been adopted for the electric plant for the following reasons :—

1. Absence of commutators on both generator and motors.

2. The more mechanical design and construction of the generator and motors, the windings of the latter, being entirely enclosed by the iron frame of the machine, protecting them from accidental damage.

3. The fact that the three-phase motors can be left running for long periods without any attention, which is not advisable in the case of direct-current motors.

4. The freedom from possibility of breakdown as compared with the direct-current system. W. G. R.

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364. *Glasgow Electric Tramways.* (Electrician, 42. pp. 104–109, 1898.)—Two and half miles of track between Glasgow and Springburn have been experimentally equipped with trolley system; 100-lb. rails, rolled in 45 ft. lengths by the Barrow Steel Co., are bonded with Daniel bonds. The poles, overhead equipment and cars were all made in Great Britain. Where centre poles are used, the trolley wire is carried on fiddle-string supports, which give an easier passage to the trolley wheel than the ordinary rigid American support. Section boxes at every half-mile connect through switches to the feeders, and also contain lighting arresters and telephones. Each of the 25 cars (mostly single decked) has two 55-H.P. motors of the usual American pattern. Important experiments on electric brakes are in progress. The power station is independent from the lighting station and contains Babcock boilers, Vicar's coking stokers, McIntosh and Seymour engines and Westinghouse generators rated at 200 kw., also a standard Westinghouse switchboard. A cooling-tower with fan draught is used for the condensing water. Cars are run with $2\frac{1}{2}$ minutes headway at an average speed of 7 m.p.h. E. H. C.-H.

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365. *Swing-Bridge Crossing.* **E. Dieudonné.** (Écl. Électr. 16. pp. 353–360, 1898.)—Apropos of the Alexandria Tramways, detailed drawings are given of the contact devices where the line crosses a swing bridge. E. H. C.-H.

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366. *New Haven and Hartford Electric Railways.* **H. N. Heft.** (Street Rly. Journ. 14. pp. 540–542, 1898.)—Some description is given of the new trucks made by the Baldwin Locomotive Works for these lines. A few more details are also given of the construction and working of the lines (see 1898, Abstracts Nos. 218 and 716). W. R. C.

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367. *Electric Traction.* **A. H. Armstrong.** (Amer. Instit. Elect. Engin. 15. pp. 399–414, 1898.)—A paper dealing with the advantages of rapid acceleration, on the lines given by Steinmetz (see 1898, Abstract No. 346). The effect is also considered of constructing the permanent way with gradients leading up to and from the stations, and the most suitable length of gradient to employ when the stations are at short distances apart. W. R. C.

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368. *Cost of Electrical Energy for Tramways.* **R. W. Conant.** (Eng. News, 40. pp. 181–183, 1898.)—This is an analysis of the results obtained at forty-four power stations during the past year.

The author adopts the kilowatt-hour in preference to the car-mile as a standard of reference, and compares the working of the various stations with that of a standard station operating under the most favourable conditions. The equipment of the standard station is assumed to consist of three 1,200-kw. steam dynamos and six 500-H.P. water-tube boilers, with the usual accessories, the estimated costs being approximately as follows :—

	£
Buildings, foundations for machinery, chimney, coal handling apparatus, &c.	25,000
Engines and condensers, heaters, separators and piping	19,135
Feed pumps and economisers	3,750
Boilers and flues	12,700
Generators and switchboard	15,375
Land and docking facilities	3,540
Engineering and sundries	1,040
Total	£80,540
Cost per kilowatt capacity	£22·4

On the basis of an annual output of 10,500,000 kw.-hours, with a load factor of 33·3 per cent., the working expenses are :—

	d.
Interest, depreciation and taxes	0·20
Labour	0·08
Fuel at 14/- per ton	0·16
General expenses	0·05
Total per kw.-hour	0·49

Simple rules and diagrams are given for finding the costs of labour and fuel under various conditions of price of coal and labour, load factor, efficiency, &c. Other diagrams and tables show the actual cost of the respective items at several selected stations at different seasons, compared with the values estimated for the standard station. Usually the fixed charges, cost of fuel, cost of labour, and general expenses, are roughly in the ratio 4 : 4 : 2 : 1. The items of expense in some of the cases are discussed and explained. At three existing stations the working cost per kw.-hour is less than that given for the standard station.

A. H. A.

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369. "*Anderson*" *Closed-Conduit System.* (Electrician, 42. pp. 38–39, 1898.)—The collector bar on the car makes contact with a pin which, when the car comes over it, rises 4 inches above road level while at the same time it becomes "alive." The short length of line now being tried at Leeds has not yet demon-

strated whether frost or wear and tear can interfere with the falling back of the contact pin into the safety position. The inventor states the cost of the surface contact boxes for the half-mile of experimental line at £600, but expects large reduction in price for quantities. E. H. C.-H.

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370. *Siemens and Halske Conduit Systems.* **G. Braun.** (Elect. World, 32. pp. 392–395, 1898. Abstracted from Elektrotechnische Zeitschrift.)—In the Budapest system there is an egg-shaped concrete conduit under one rail, containing two angle-iron conducting rails, one at each side of the conduit, fastened to the yokes by means of insulators. The yokes, placed at a distance, of 1·2 metres, support and maintain at the proper distance from each other the two halves of the tram rail which serves also as a slot rail, *i.e.*, the slot is not midway between the rails but coincides with the groove of one of them. The wheel flange is in the middle of the tyre. The pick-up device is two cast-iron shoes attached to a plough and pressing laterally outwards into the angle of the conducting rails. The conduits drain to sumps and are cleared out by egg-shaped shifters attached to a plough. As compared with American conduit practice the Budapest system has the advantage that less iron is required on the surface of the street. Points are a difficulty owing to necessity for retaining the full sectional profile of both the conduits. Diagrams show the devices adopted. To facilitate rapid change from conduit to trolley the plough is automatically ejected at the required point by an inclination in the floor of the conduit. In 1896, four million car kilometers were run in Budapest on this system. In Germany a similar system with ground return is being used. The conduits are completely interrupted at points and crossings, the ploughs being automatically ejected and then reinserted. E. H. C.-H.

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371. *Maxham Third Rail System.* **L. M. Maxham.** (Elect. Engin. N.Y., 26. pp. 439–440, 1898.)—Hollow sectional third rails are laid in the centre of the track and contain the insulated live line. Alongside the hollow rails runs a guard-rail so placed as to form a slot. Normally an insulating tongue fills this slot flush with the road; the car carries a cam which depresses the insulated tongue, thereby mechanically bringing the conductor into contact with the section of hollow rails over which the car is passing. Safety is claimed for the system, but no precaution seems to be taken to prevent the section being made alive by accidental pressure upon the insulated tongue. E. H. C.-H.

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372. *Surface Contact Systems.* (Zeitschr. Elektrotechn. Wien, 16. pp. 443–446, 1898.)—The various surface-contact systems

form the subject of this article. Descriptions are given of two systems of F. C. Esmond, and also of the system patented by the Union Elektricitaets-Gesellschaft, Berlin. E. H. C.-H.

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373. *Tramway Track Construction in Sioux City.* **C. P. Wilson.** (Street Rly. Journ. 14. pp. 439–442, 1898.)—The track consists of 60-lb. T rail on steel sleepers. After the rails were placed in position a longitudinal concrete beam, 15″ wide by 9″ deep, was formed under them as a foundation the whole length of the track. Extracts are given from the specifications. W. R. C.

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374. *Bow Form of Trolley.* **Stobrawa.** (Electricien, 16. pp. 97–100, 1898.)—To reduce the weight of the bow it is now frequently made of aluminium with white-metal rubbing surfaces. The old square form has given place to the triangular form which makes it impossible for the wire to lodge underneath the bow, when it is liable to wreck the overhead system. In Dresden the life of a bow covered with white-metal is about two weeks, while if made of aluminium it lasts eight weeks, corresponding to about eight car-kilometres. The cost of maintenance works out at Basle and at Dresden at 0·0875 centime per car-kilometre. Use of an annular contact surface facilitates the use of a lubricant which has the double advantage of making the sliding noiseless and rendering easy the removal of ice in winter. In Dresden the tension on the springs is specified not to exceed 3·5 kilogrammes. At curves an extra wire is used to prevent the bow striking cross wires. After four years' use it was found that the section of trolley wire was reduced to 96 per cent. of the original, owing to friction of the bow, but in this particular the bow is superior to the trolley as the latter also wears the side of the wire at curves. In the case of a bow the extra wear at curves falls on the additional guiding wire which is easily replaced. E. H. C.-H.

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375. *Rail Bonds.* (Street Rly. Journ. 14. pp. 519–523, 1898.)—An account of the more recent methods of bonding. W. R. C.

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376. *Line Poles.* (Street Rly. Rev. 8. pp. 241–244, 1898.)—Data are given with regard to comparative merit of poles of different kinds and settings for carrying electric lines. A sound wooden pole, with precautions taken for preservation, should last from eight to ten years, but this life may be greatly lengthened or shortened according to the various circumstances. The cost

of iron poles is prohibitive, except in the larger American cities, and the kind of wood selected depends on the locality. Pine is one of the most perfect and symmetrical of all timbers, and has a good tensile strength. In some cities, however, wooden poles are not permitted, and many street-railways use iron poles on account of their superior strength, longer life, and better appearance. The North and West Chicago Street Railways have a cast-iron sleeve, 2 in. thick, which is slipped over the pole and extends some distance above and beneath the surface of the street. This has proved very effective in preventing the poles from rusting at this point. The author emphasises the importance of painting the poles with the right paint, and gives details as to the best preparations to use for this purpose. Illustrations are given of the span wire arrangements for single and double tracks, and also of the arrangement of poles in use at Dover, Berlin, and Leeds. L. J. S.

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377. *Inspection of Car Equipments.* **F. B. Perkins.** (Elect. Engin. 22. pp. 461–463, 1898.)—The author advocates daily rather than monthly inspection of cars. For a 50-car house with handling facilities five inspectors are recommended, two to attend to the motors, one to the controllers, one to the trolleys, and one to the trucks and car-bodies. Brushes should be treated with oil every few days, thereby materially increasing their life and minimising sparking. Every controller should be inspected and its contacts vaselined every fourth day. Inspection on the road is not recommended. All supplies should be tested before use. E. H. C.-H.

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378. *Car Trucks.* (Eng. News. 40. pp. 164–166, 1898.)—This article describes a number of different types of trucks, dividing them into two classes: (1) trucks having springs over the axle boxes, (2) trucks having springs under the ends of the bolsters. The first class includes Ajax, Black Diamond, Cloud, Fox, Joughins, Kindl and Schoen trucks, while the second comprises the American, Haskell and Barker, N. Pacific Railway, Player, and Schoen trucks. E. H. C.-H.

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379. *Single and Double Truck Cars.* **R. McCulloch.** (Elect. Engin. N.Y., 26. pp. 251–254, 1898.)—Twenty-two feet is about the limiting length of body of a single truck car: beyond this length double trucks must be used to avoid oscillation and grinding on curves. The expenses of the average city road may be divided up as follows: Maintenance of way and structures, 4 per cent.; maintenance of equipment, 7 per cent.; conducting transportation, 52 per cent.; general expenses, 8 per cent.; fixed charges, 29 per cent. If we reduce the number of cars by in-

creasing them in size we shall reduce the heaviest item (viz., conducting transportation) almost in proportion. Detailed tables are given comparing single and double trucks on the following points: (1) Cost of wheels and brake shoes per annum. (2) Repairs of trucks and motors. (3) Power required. (4) Weights carried empty and full. Taking into account the number of passengers carried, it appears that the costs under these various headings are about equal for single and double trucks. The trouble with maximum traction trucks getting off the line was due to the small weight put upon the trailers. Thirty per cent. of the weight is now put on the small wheels. In the discussion on this paper **J. I. Beggs** mentioned that at Milwaukee ten interurban cars were in use equipped with 4 "G.E. 1,000" motors geared to 26 miles per hour, weighted with 40,000 lbs., the cars weighing about 35,000 lbs. E. H. C.-H.

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380. *Peckham Maximum Traction Truck.* (Street Rly. Journ. 14. pp. 555–556, 1898.)—A new truck, No. 14 D 2 of the Peckham Truck Company, is illustrated and described. The special features are that it is centre-bearing and is fitted with a swing bolster; thus the truck wheels and car body are relieved from side thrusts on curves at high speed, and the trailing wheels are prevented from jumping the track. E. H. C.-H.

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381. *Cab Charging Station.* (Elect. World, 32. pp. 227–232, 1898.)—This article describes a new station of the New York Electric Vehicle Company, capable of accommodating 200 car-batteries simultaneously. The cabs are driven by motors geared to the forward wheels, and supplied with current from the battery box situated under the driver's seat. The 36-in. wheels consist of two solid steel discs 1/16 in. thick, carrying, on wooden rims, 5 in. single-tube pneumatic tyres, whose rubber walls are $\frac{3}{4}$ in. thick. The batteries contain 48 chloride cells of the F. V. type, mounted on one tray, the whole equipment weighing 1,300 lbs. The plates are separated by perforated, corrugated, hard rubber sheets. Speed variation is obtained by placing divisions of the battery in series or parallel, and, for the highest speed, by connecting the series field coils of the motors in parallel instead of in series. The motors are rated at 2 H.P. at 700 R.P.M., equivalent to a speed of 12 M.P.H. Elaborate arrangements are made to enable one man to remove the batteries from the vehicle, place them in position on a charging table, and return them to the vehicle when charged. In dismounting the cells, the weight of the cab is taken off the springs by hydraulic cylinders, and the battery is then withdrawn hydraulically and pushed on to a conveyor table, whence it is carried to a charging table by a special travelling crane.

Current is supplied to the batteries from one of four sets of bus bars, with pressures differing from each other by about five volts. By an arrangement of red and green signal lamps, the attendant is warned when to connect the cells on to the highest pressure. E. H. C.-H.

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382. *Motor-car Trials in France.* **E. Hospitalier.** (Ind. Élect. 7. pp. 272–286, 1898.)—This article illustrates and describes in detail the various motor-cars which took part in the trials carried out by the Automobile Club of France, June 1–11, 1898. All the cars used "Fulmen" accumulators and, with two exceptions, "Michelin" tyres. Five pages are occupied with tables showing the principal dimensions, characteristics, weights, loads, mechanical arrangements, &c., of the vehicles, together with the results of the trials, which included tests of the brakes and of power-consumption on different classes of road. In conclusion, the author remarks that he will be satisfied if next year's trials prove that the electric cab is practicable, and predicts that in two years' time it will have been shown to be economical. E. H. C.-H.

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383. *Motor-cars.* **E. Hospitalier.** (Ind. Élect. 7. pp. 287–299, 1898.)—The author gives some account of the exhibition organised by the Automobile Club of France in the Tuileries. Two hundred and fifty motor-cars were shown. Thirty of these were electrical, and are illustrated and described in detail under four headings:—(1) Cabs and other vehicles plying for hire. (2) Private conveyances manœuvred by a coachman. (3) Private conveyances manœuvred by the owner. (4) Delivery vans. E. H. C.-H.

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384. *Electric Motor-cars.* **J. Reyval.** (Écl. Électr. 16. pp. 453–456, 1898.)—The Bouquet, Garcin et Shivre (B.G.S.) system is peculiar in a few points. Special accumulators are used weighing only 350 kg. on a vehicle weighing 1,000 kg. (gross) which is capable of running 100 to 150 km. with one charge. The armature of the motors is wound in two unequal sections, the number of turns being in the ratio of 5 to 3. By this means seven speeds can be obtained without altering the arrangement of the cells or varying the motor-fields. E. H. C.-H.

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385. *Electric Motor-cars.* (Elect. World, 32. pp. 483–488, 1898.)—Three illustrated articles describe electric vehicles made by the Pope Manufacturing Co., the Riker Electric Motor Co., and the General Electric Automobile Club. E. H. C.-H.

386. *Cost of Electrical Energy.* **M. E. Turner.** (Elect. World, 32. pp. 209–210, 1898.)—This paper is intended to illustrate the Wright system of charging for electrical energy, and consists chiefly of a discussion of the correct apportionment of each item of expenditure between fixed and running expenses. On certain assumptions, the following conclusions are based :—

	Fixed Expenses.	Running Expenses.	Total per kw. hr.
Cost of 1 kw. for 1 hour per day	14d.	0·5d.	14·5d.
,, ,, 2 hours ,, ...	14d.	1·0d.	7·5d.

A. H. A.

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387. *Charging for Electrical Energy.* **A. Meynier.** (Ind. Élect. 7. pp. 377–378, 1898.)—The rational charge for electrical energy depends upon the following conditions :—

1. Local conditions.
2. The duration of the utilisation of the energy.
3. The time at which the energy is used; day or night, summer or winter.
4. The importance of the consumer.

It ought not to depend upon the use to which the energy is applied.

In order to be favourable to good clients, the author suggests that a reduction y in the charge should be given, where

$$y = a - \frac{b}{x+k}$$

x being the number of 16 C.P. lamps installed, and a, b, and k certain constants dependent upon the other conditions. An additional reduction should be made proportional to the ratio of the watts used to the number of lamps installed. W. G. R.

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388. *Incandescent Lamps.* **S. E. Doane.** (Elect. World, 31. pp. 785–787, 1898.)—Change of resistance has little to do with alteration in candle power of a lamp, and any change in C.P. without a change in watt-consumption is due to alteration in the surface of the filament. Almost all lamps rise rapidly in C.P. during the first two or three hours of use, but afterwards the curve of C.P. falls almost in a straight line. Blackening of the lamp bulb, which is largely a chemical effect, is responsible for very little of the drop in C.P., most of it being accounted for by the increase in area of the filament surface. E. H. C.-H.

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389. *Cotsworth Arc Lamp.* (Elect. Engin. 21. p. 779, 1898; British Patents Nos. 23462 of 1895 and 17832 of 1896.)—This is a clutch lamp in which the brake-block is mounted on a spring which is attached to the end of a swinging lever acted upon by the regulating electromagnet. The lamp is a focussing one, a coil passing over the brake-wheel and connecting the rods carrying the carbons; these rods are square and rest in a right-angled V-groove in the periphery of the brake-wheel. Another feature of the lamp is the globe-lowering gear. This comprises two rods which support the globe and are arranged on opposite sides of the lamp and have valved pistons at their ends working in tubes in the cover. These valved pistons allow the globe to be raised rapidly, but on descending the valves close and prevent the globe from falling too quickly. Catches are provided for locking the rods in their uppermost position. C. K. F.

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390. *Electric Train Lighting.* (Railroad Gazette, 30. pp. 668–669, 1898.)—The Stone system of lighting railway trains, by means of accumulators and a dynamo driven from the axle of the guard's van is described. The dynamo is so suspended that the tension of the belt cannot exceed a certain prearranged limit, beyond which the belt slips on the pulley, while the armature is driven at a constant speed. A mechanical governor switches the accumulators off when the train slackens speed. Experiments show that the dynamo speed is constant while the speed of the train varies from 24 to 72 miles per hour. The power absorbed is from 0·6 to 1·1 H.P. for an ordinary coach, consuming about 0·05 lb. coal per coach per mile. A. H. A.

TELEGRAPHY AND TELEPHONY.

391. *Telephone Central Equipment.* **H. P. Clausen.** (West. Electn. 23. pp. 2–3, 1898.)—The "multiple-plug" system depends on multiplying the calling instead of the called connections as in the multiple-jack. It is cheaper in first cost if there are two or three thousand subscribers. The Dalmarvia system is described in some detail. M. O'G.

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392. *Telephone Indicator.* **P. Rabbridge.** (Elect. Rev. 43. p. 731, 1898.)—The one described consists of a permanent magnet on the keeper of which is wound a coil, which releases the keeper if influenced by a signal current. M. O'G.

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393. *Luminous Signal Boards.* **K. B. Miller.** (Amer. Electn. 10. pp. 433–436, 1898.)—The direct and relay connections are shown. The lamps will stand a million signals and last twenty-five years. M. O'G.

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394. *Automatic Telephone Board.* (Electrician, 41. pp. 522–523, 1898.)—Referring to Electrician, May 6th, p. 52, the author outlines the "bridging system" whereby any one of 10,000 subscribers may be selected and called. M. O'G.

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395. *Telephone Call Dials on Series System.* **L. Montillot.** (Électricien, 16. pp. 119–122, 1898.)—When station A wishes to call station G which is on the same line and in series with stations B, C, D, without disturbing them, A starts an electrically wound clock in all the stations, and at the moment his own pointer passes the G engraved on his dial he depresses a key and secures G's attention. Full details are given. M. O'G.

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396. *Combined Telephone and Electric Light Stations.* **H. P. Clausen.** (West. Electn. 22. pp. 332–333, 1898.)—The same linesmen, trenchwork, and centres are available. Protective devices are explained. M. O'G.

SCIENCE ABSTRACTS.

PHYSICS AND ELECTRICAL ENGINEERING.

MARCH 1899.

GENERAL PHYSICS.

397. *Density of Ice.* **E. L. Nichols.** (Phys. Rev. 8. pp. 21–37, 1899.)—Four different kinds of ice were examined: Ice mantles produced by means of CO_2 and ether, natural ice in icicles, pond ice newly cut, and pond ice one year old. The natural ice was always found to be denser than the artificial ice, when both were quite clear and free from air-bubbles. The mean density of the former was 0·9182 at 0°, of the latter 0·9174.

E. E. F.

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398. *Solution Densities.* **H. T. Barnes** and **A. P. Scott.** (Journ. Phys. Chem. 2. pp. 536–550, 1898.)—When a little zinc sulphate is added to water, no change in the volume of the water is observed until a density of about 1·150 is reached. After that, one molecule of zinc sulphate seems to displace one molecule of water. Experimenting with various sulphates, nitrates and chlorides, and also with sulphuric and hydrochloric acids, using a 10 c.c. pyknometer of Ostwald, the authors find that none of these solutions shows the flat part of the curve so strikingly as zinc sulphate. The molecule of salt seems to displace several molecules of water, but not less than one, and the density curve appears sometimes to start out to follow a one molecule relation, and then to bend into a two or three molecule relation or *vice versâ*. The authors consider the chemical analyses as the least reliable part of their work, but they do not appear to have purified their salts.

H. B.

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399. *Density and Ductility.* **L. Grunmach.** (Wied. Annalen, 67. 1. pp. 227–232, 1899.)—A rod of Siemens-Martin flux

iron is turned in successive steps of lesser diameter, followed by successive steps of increasing diameter. In this shape the specimen is stretched until it breaks. The several steps are then cut asunder, and on determining their specific gravities it is found that that of the centre piece where the breaking took place is 0·5 per cent. less than that of the other pieces. E. E. F.

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400. *Capillary Angles.* **A. Rota.** (Roma R. Accad. Lincei Atti. 7. 2. pp. 125–129, 1898.)—The angle between alum and its saturated solution is 10° 16′ when the crystal is octahedral and the solution also such as to form octahedral crystals: 10° 22′ between a cubical crystal and a cube-crystal forming solution; 15° 36′ between a cube-crystal and an octahedron solution; and 15° 13′ between an octahedron and a cube solution. A. D.

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401. *Cohesion of Mercurial Columns.* **A. Pizzarello.** (N. Cimento, 8. 4. pp. 266–270, 1898.)—Columns of mercury more than 2·2 metres high can be sustained in glass tubes even against an external vacuum, by cohesion of the column and adhesion to the glass. A new piezometer is described. A. D.

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402. *Elasticity in Compound Pendulums.* **Helmert.** (Astron. Nachr. No. 3430 and Beitr. z. Theor. d. Reversionspendels, discussed by **P. Pizzetti** in N. Cimento, 8. 4. pp. 215–220, 1898.) —The corrections for elasticity are of such an order that they reduce an apparent length, in a particular case, of 994·626 mm. to one of 994·260 mm. The other sources of error are also carefully discussed. A. D.

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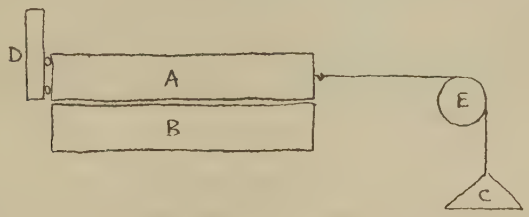
403. *Molecular Contact.* **J. S. Stevens.** (Phys. Rev. 8. pp. 49–53, 1899.)—In working with the interferometer, the author noticed that the brass plate which carries the movable mirror could be very slightly displaced along the bed upon which it lies, and that on releasing the pressure producing the displacement the fringes would return to their original position. To further study this effect, he measured the displacements for given weights applied to move the mirror-plate, using various metals for the two plates. In the accompanying diagram, D is the mirror fastened with wax on one end of the upper plate A. The displacement was produced by weights put into the scale-pan C, attached to A by a cord passing over the pulley E. The displacement ob-

served was nearly the same in brass, copper, iron, and steel, and amounted to three or four wave-lengths of sodium light. In the case of steel on steel it amounted to seven wave-lengths before sliding set in. The displacement is in every case nearly (probably exactly) proportional to the force applied. This holds for rough and smooth, for similar and dissimilar surfaces. It is evident that when the force applied is not



sufficient to produce a complete rupture between the molecules in contact, an additional stress is set up, which brings about the return of the plate to its original position when the force is removed. E. E. F.

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404. *Mechanical Resistance of Air.*— **O. Mannesmann.** (Wied. Annalen, 67. 1. pp. 105–131, 1899.)—The experiments are carried out by means of an improved rotation apparatus. A circular metallic plate is mounted on a horizontal arm and driven either by a water motor or an electromotor. It is capable of sliding forwards and backwards in the direction of motion, and in sliding backwards it pulls a cord leading to the centre of the axis of rotation, where a weight is attached to the cord. The amount by which the weight is lifted indicates the pressure on the plate, and this amount is shown on a large scale by an aluminium pointer. The author experimented on various plane and curved surfaces, the latter consisting of aluminium sheets "pressed" upon cast-iron spheres. He found that the resistance per unit of surface increased with the curvature in the case of concave surfaces, but that it was less than the normal amount in perforated surfaces —a fact which has a bearing upon sailing practice. With inclined planes, the maximum lifting effect (*Auftrieb*) is obtained at about 42° to the horizon. With slightly concave surfaces the angle is higher. The resistance increases with the temperature and the barometric pressure. When two plates are mounted one behind the other, their total resistance is less than double that of a single plate, but it becomes more than that when the distance apart attains a certain value. E. E. F.

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405. *New Volumenometer.* **A. Oberbeck.** (Wied. Annalen, 67. 1. pp. 209–216, 1899.)—Two glass tubes provided with divided scales are fixed side by side on a board. At one end of the board they join, and are connected with a mercury reservoir. At the other end each tube is provided with an expansion in the shape of a beaker, which has a ground edge and can be closed air-tight. When this is done, and the board is inclined, the mercury falls by equal amounts along both tubes. But if the body whose volume is to be determined is introduced into one of the beakers, the mercury in the corresponding tube falls to a lesser extent. The author shows how to determine the volume from the data thus provided. E. E. F

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406. *Diffusive Convection.* **A. Griffiths.** (Phil. Mag. 46. pp. 453–465, 1898.)—This is a mathematical paper on the phenomena of diffusive convection. The case is considered of a vessel divided into two parts by a horizontal diaphragm through which two narrow tubes pass. The lower part of the vessel is filled with a solution of copper sulphate, the upper with pure water. While the tops of the two tubes are in the same horizontal plane in the water, one of the tubes descends to a lower level in the solution than the other. Under these circumstances, when things have attained a steady state, there will be a flow up the longer tube and down the shorter one. The author considers (1) the case of diffusion of a salt in a vertical tube through which the liquid is flowing with constant velocity, when the steady state has been attained; (2) the determination of the magnitude of the convection current in the case of tubes of equal bore, neglecting viscosity; (3) the effect of diffusive convection on the quantity of dissolved substance transmitted when the tubes are of equal bore and when they are of unequal bore; (4) the probable effect of viscosity on the convective flow; and finally describes an apparatus designed to illustrate experimentally diffusive velocity. The author is led to suggest that the heat produced on mixing a solution with water may depend on how the mixing takes place. Perhaps the matter may be connected with a sort of surface tension existing in the spaces between a strong and weak solution. J. J. S.

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407. *Equilibrium Figures.* **R. W. Wood.** (Phil. Mag. 46. pp. 162–164, 1898.)—Equilibrium figures (as in Meyer's floating magnets experiment) may be produced by dropping clean bicycle balls into clean mercury above a vertical electromagnet. In a larger group a larger ball ploughs its way to the centre. A. D.

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408. *Pressure on Collision of two Explosion-waves.* **R. H. Jones** and **J. Bower.** (Mem. Manchester Lit. and Phil. Soc. 42. 7. pp. 1–7, 1897–8.)—An explosion-wave is partially checked by an imperfect junction in the apparatus, becomes less luminous, and does not recoup itself for some seven or eight inches. From the point of redetermination a back wave runs, and the tube almost invariably breaks at this point of redetermination. There is an actual increase of pressure on collision of two explosion-waves. Two rebound-waves start from the point of collision in opposite directions along the tube. These are sound-waves, made brightly luminous by passing through the still heated gases. A similar sound-wave is produced when an explosion takes place in a glass tube closed at one end, rebounding from the end surface and travelling back along the tube; but the rebound in this case is slower ($\frac{10}{13}$) than when two explosion-waves meet. A. D.

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409. *Propagation of Liquid Waves.* **G. Poisson.** (Comptes Rendus, 128. pp. 42–45, 1899.)—Under the assumptions that in any given form of watercourse the variations of section and slope only occur gradually, and that the longitudinal slope is so small that the angle is equal to its sine, the author shows how to calculate the maximum height of a wave in every part of the course and the corresponding speed. The waves need not be of infinitesimal height. E. E. F.

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410. *Longitudinal Waves.* **G. Bongiovanni.** (N. Cimento, 8. 4. pp. 61–66, 1898.)—A discussion of the use of a cylindrical spiral of wire to demonstrate stationary longitudinal waves and of the methods of ascertaining the contents of the spiral. A. D.

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411. *Muscular Elasticity.* **A. Chauveau.** (Comptes Rendus, 127. pp. 983–992, 1898.)—With the help of new registering apparatus, only referred to, in which the weights of the fore-arm and hand are counterpoised, and the tenacity of the muscle is neutralised, Chauveau has again studied the elastic force of the muscles. He distinguishes between the load p which a contracted muscle sustains and the load P, up to 2·5 kg. in his experiments, which produces a certain extension l of the muscle. In mechanics, $l=\frac{PL}{CS}$, where S is the sectional area, and C the co-efficient of elasticity resistance to extension. For the muscle, he finds $l=\frac{P}{p}$. The same load always produces the same extension, no matter which contraction we start from; and the same load is always required to make a certain additional contraction disappear. The curves are strikingly regular. H. B.

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412. *Muscular Action.* **Z. Treves.** (Torino R. Accad. Sci. Atti, 33. pp. 227–250, 1897–8.)—An overloaded muscle, rhythmically excited to contraction, gives oscillations of rapidly and greatly diminishing amplitude, and the muscle quickly becomes exhausted. When the stimulation and the load are such as to give the maximum work (weight × lift) the oscillations are constant in amplitude and the work remains constant for long periods of time; but these oscillations have a smaller amplitude than that of which the fresh muscle is capable with smaller loads. These smaller loads, however, give less work at each contraction. Under the condition of maximum work the subjective impression is one of a kind of unconsciousness of the work which is being done; this comes on after a preliminary feeling of fatigue. After a period of repose an overloaded muscle can again execute wider oscillations, again to fall off rapidly to small minima as before. Voluntary excitation of a muscle brings out higher values for the maximum work than electrical stimulation does. A. D.

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413. *Mechanical Illustration of Energy apparently Potential but really Kinetic.* **E. Merritt.** (Phys. Rev. 7. pp. 106–114, 1898.)—The employment of generalised co-ordinates makes it possible to discuss almost all branches of physics and show that they conform to mechanical principles, even when the details of the processes involved are not known. A difficulty sometimes arises, however, in attempts of this kind on account of the impossibility of distinguishing between potential and kinetic energy. In the case of the magnetic and electrostatic fields, for example, if we think of the field as being in a state of strain, the energy is regarded as potential; whereas if we consider the field as due to some condition of motion in the ether, its energy is properly regarded as kinetic. So long as we do not know what really goes on in the field, it is impossible to decide which of these two views is correct. In this case, as in many similar ones, it is possible to discuss the problem by the aid of generalised co-ordinates and to obtain correct results, no matter which hypothesis is made as to the character of the energy. The matter is much simplified, however, if the view be accepted that in reality all energy is kinetic, whether it be the energy of moving bodies of finite size or the energy of some motion whose existence can only be imagined.

According to this hypothesis, the energy due to a strained condition, such as that of a stretched spring, would in reality be the energy of some more or less complicated motion of the ether; this motion would be looked upon as the cause of the strain, and, in fact, as constituting the strained condition. If work is done against gravity in lifting a weight, it is usual to speak of this work as being stored in the form of potential energy; yet it is equally plausible to say that the work done in lifting the weight reappears as the kinetic energy of something analogous to eddies in the

ether, these being brought into existence by the movement. This motion will continue as long as the body occupies its new position, and may be the cause of the force tending to make it fall. When the body is allowed to fall, the energy stored in this motion of the ether is given back again and appears as visible motion.

The author then passes to the mathematical discussion of a mechanical system, in general very complex, in which the energy is in reality all kinetic. The position of every particle being completely specified by the generalised co-ordinates ϕ_1, ϕ_2, the kinetic energy T is given by

$$T = f(\phi_1, \phi_2, \ldots, \dot{\phi}_1, \dot{\phi}_2, \ldots) \qquad (1)$$

where f is homogeneous and quadratic as regards the generalised velocities $\dot{\phi}_1$, $\dot{\phi}_2$, . . . If Φ_n is the generalised force acting to increase ϕ_n the equations of motion will take the form—

$$\frac{d}{dt}\frac{\partial T}{\partial \dot{\phi}_n} - \frac{\partial T}{\partial \phi_n} = \Phi_n \qquad (2)$$

It is next assumed that the existence of certain essential co-ordinates is unknown to an observer who is studying the system in question. These unknown or concealed co-ordinates are denoted by ψ_1, ψ_2, . . . If certain restrictions are placed upon these co-ordinates and the motions corresponding to them, they may be made to explain the existence of apparent potential energy.

The necessary restrictions are: (1) That the concealed co-ordinates enter the expression for T only as velocities, *i.e.*, the $\dot{\psi}$'s appear in this expression, but not the ψ's themselves; (2) no outside forces act to change the concealed co-ordinates; (3) terms of the form $\dot{\phi}_m \dot{\psi}_n$ do not appear in the expression for T. When these assumptions are made the expression for the kinetic energy may be separated into two parts such that

$$T = f_1(\phi_1, \phi_2 \ldots \dot{\phi}_1, \dot{\phi}_2 \ldots) + f_2(\phi_1, \phi_2 \ldots \dot{\psi}_1, \dot{\psi}_2 \ldots) \qquad (3)$$

where f_1 contains only the known co-ordinates and their time derivations, while f_2 contains the known co-ordinates and the velocities of the concealed co-ordinates. Since no outside forces act to change the velocities of the concealed co-ordinates, the values of $\dot{\psi}_1$, $\dot{\psi}_2$, &c., will depend only upon the configuration of the system, *i.e.*, each of the $\dot{\psi}$'s is a function of the known co-ordinates only.

An observer ignorant of the existence of the concealed co-ordinates would naturally look upon f_2 as the expression for the *potential energy* of the system, for when the $\dot{\psi}$'s have been eliminated f_2 will appear to be a function of position only; f_1, on the other hand, being homogeneous and quadratic in the $\dot{\phi}$'s, would doubtless be accepted as the complete expression for the

kinetic energy. This assumption of potential energy, when in reality none exists, would not merely be extremely plausible, but its incorrectness would also be difficult of proof; for all predictions based upon it regarding the behaviour of the system would be correct so far as they could be experimentally tested.

After further developing this general treatment, the paper concludes with the following concrete example:—

At each end of a rod of length $2r$ is mounted a mass m, whose dimensions are so small as compared to the length r that the mass may be looked upon as concentrated at a point. The rod is pivoted at the centre so as to be carried by the arm R in its rotation about the vertical shaft SS, to which, either directly or by means of a belt, is attached a heavy fly-wheel. The problem is further simplified if the inertia of this fly-wheel is so great that the angular velocity, ω, of the shaft will not be appreciably modified by any change in the position of the rod rr and its attached weights.

It is then shown on dynamical principles that, as the shaft SS rotates with angular velocity ω, the masses $m\,m'$ will vibrate about the horizontal position with period $2\pi/\omega$.

An observer of this motion is now supposed to be carried round with the arm R in its rotation, the conditions being such that he is not only ignorant of the mechanism of the apparatus that carries him, but is actually unaware of the fact that he is moving. Such an observer would notice that the system $m\ m'$ had a definite position of equilibrium, and that when displaced from this position a force tended to make it return. It would accordingly be most natural for him to assume that the system possessed potential energy when displaced, this energy being equal in amount to the work done during the displacement.

Following up this line of thought, it would be inferred that the system has, in addition to the kinetic energy $mr^2\,\dot{\theta}^2$, an amount of *potential* energy equal to $-mr^2\,\omega^2\cos^2\theta+\text{constant}$; whereas, what the system really possesses is the additional *kinetic* energy

$$+mr^2\,\omega^2\cos^2\theta+\text{constant}.$$

The opposite algebraical signs in the two cases apparently lead to a violation of the principle of the conservation of energy. The explanation lies in the term involving the moment of inertia K of the fly-wheel. If, as supposed, the variations in ω are small, it must be that K is large; hence the product $\frac{1}{2}\,\mathrm{K}\,\omega^2$ will be subject to changes comparable in magnitude with the others under examination. It is thus shown finally that on the hypothesis of potential energy the term $-mr^2\,\omega^2\cos^2\theta+\text{constant}$ in reality takes the place of the two terms $\frac{1}{2}\,\mathrm{K}\,\omega^2+mr^2\,\omega^2\cos^2\theta$ in the energy expression, and that the value of the total energy remains unaltered, as it should, no matter which assumption is made regarding the distribution of energy between the two forms, kinetic and potential. E. H. B.

414. *Forced Precession and Nutations of an Ellipsoidal Shell.* **W. McF. Orr.** (Phil. Mag. 46. pp. 545–553, 1898.)—The author calculates the difference between the precession and nutations of an oblate ellipsoid of revolution on the hypotheses of its being perfectly rigid and of its being filled with homogeneous incompressible liquid. He refers to results stated for the same problem by Kelvin, who, however, does not give the analyis. A A′ are the moments of inertia about an equatorial axis for the shell and liquid respectively, C C′ the corresponding moments about the axis of figure. The axes of the cavity are α, γ; m is the mass of the liquid, also

$$\mu = \tfrac{1}{5} m\,(\alpha^2 - \gamma^2),\ \varepsilon = (\alpha^2 - \gamma^2)/(\alpha^2 + \gamma^2)$$

If the axes of the disturbing couple turn relative to the shell with constant angular velocity κ in the same direction as the shell rotates, the component couples about the axes of x and y in the plane of the equator are the real parts of Le^{ikt} and Me^{ikt} where $L = iM$. Let n be the constant angular velocity round the polar axis, and let $\sigma = n + \kappa$.

In the notation of Routh's diagram let θ be the angle ZC, ψ the angle which ZC makes with ZX, ϕ the angle which CA makes with ZC produced. Also let α be the mean value of θ, ϕ_0 the mean value of ϕ. The author finds—

$$\theta = iMe^{i\,(\sigma - \phi_0 \cos\alpha)\,t} \Big/ (nC'' - \sigma A'')$$

where

$$nC'' - \sigma A'' = n\,(C + C') - \sigma\,(A + A') - (A' - \mu\varepsilon)\,\frac{\sigma(n-\sigma)}{\sigma + \varepsilon n}$$

If the shell and liquid formed one rigid body, the denominator would be

$$n\,(C + C') - \sigma\,(A + A')$$

From which the result is calculated according as σ is positive or negative, and if negative according as $\sigma + n\varepsilon$ is positive, zero, or negative. Kelvin, the author says, appears not to have taken into account the case of σ positive.

The result is applied to the case of the earth, but the author does not suggest that it has much practical interest. In effect he obtains results agreeing with those of Kelvin for precession and for the nineteen-yearly nutation, but differing for the half-yearly and fortnightly nutations. S. H. B.

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415. *Earthquakes in Labuan.* **G. Agamennone.** (Roma R. Accad. Lincei Atti, 7. pp. 155–162, 1898.)—The paper refers to earthquakes which took place at Labuan on the 20th and 21st of September, 1897. The author tabulates the results, and works

out the velocities of propagation from the data of ten stations. The velocities of the more rapid waves vary between 17·71 and 27·71 km. per second in the case of the first; and between 16·13 and 29·29 in the case of the second. He attributes the cause of such differences to the varying degrees of sensitiveness of the different instruments, and would like to see more delicate instruments, such as those used in the Italian, and in European observatories, and of uniform design, whereby a greater uniformity of observation would be attained. Another source of inaccuracy being that as there were no observatories nearer the scene of action than Batavia, the times of this latter station were taken as identical with those at the seismic centre. He also finds that for the greater distances, if the chord be taken instead of the arc he obtains much greater approximations to what he considers correct results. A. Gs.

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416. *Earthquake in Hayti.* **G. Agamennone.** (Roma R. Accad. Lincei Atti, 7. pp. 316–318, 1898.)—The author in this paper refers to an earthquake that occurred on Dec. 29th, 1897, in the valley of the Yaque river. The intensity of the shock was to the IX–X degree on the scale of *de Rossi-Forel*; the land influenced by the earthquake would not be less than 125,000 sq. kilometres (about 48,000 sq. miles). From the observations made at the observatory of Port au Prince the author concludes that the most rapid seismic waves are propagated with a mean velocity of 10 kilometres per sec. (6·2 miles). These waves were followed as usual by superficial undulations of slow period, having a mean velocity of 3 km. per sec. (1·86 mile).

The author considers that the Hayti earthquake proves his former assumptions, and gives a good support to his deductions in former papers. These are his most important conclusions from a very exhaustive study of the Hayti earthquake to be shortly published in the Bollettino della Società Sismologica Italiana. A. Gs.

LIGHT.

417. *Standards of Light.* **A. Blondel.** (Écl. Électr. 16. p. 317, 1898.)—The author has constructed a modified Hefner lamp of precisely the same power as the standard Hefner, in which a chimney is used so that the flame does not oscillate under a current of air, and in which either acetate of amyl or a mixture of absolute alcohol and crystallisable benzol may be employed. A. D.

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418. *Total Reflection.* **W. Voigt.** (Wied. Annalen, 67. 1. pp. 185–200, 1899.)—That even at "total reflection" some light penetrates the reflecting surface was proved by Newton by means of a third medium. The author attempts the same proof without that artifice, which, he maintains, impairs the strict validity of Newton's reasoning. He uses a prism whose base is an isosceles right-angled triangle. A line is drawn on the base from the middle of the hypotenuse to a point on one of the sides at a small distance from the end of the hypotenuse. Along this line a plane is cut parallel to the length of the prism. When light impinges upon the side surface in question, it is totally reflected by the hypotenuse and the new surface, but the junction of the two is indicated by a bright streak. E. E. F.

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419. *Orientation of the Slit in Interference Experiments.* **J. Walker.** (Phil. Mag. 46. pp. 553–557, 1898.)—This refers to a paper by the same author in the Phil. Mag. 46. pp. 472–478, 1898, and to some results obtained by Fabry. In the former paper it is shown that the relative retardation of the interfering streams from a point distant ξ from the central line of a properly orientated slit is measured in length $\alpha+\beta x+\gamma\xi$—the values of α, β, γ, being given in the present paper for the mirrors, for Fresnel's biprism, and for Billet's divided lens. The proper orientation of the slit is there defined. He now supposes the orientation of the slit to be varied by first turning it round its centre line through an angle ϕ, and then round the normal to its new plane through an angle θ, and calculates the visibility of the interference fringes in terms of ϕ and θ. The results are compared with those obtained by Fabry and Rayleigh. S. H. B.

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420. *Bright Bands produced by two Gratings.* **F. F. Martens.** (Zeitschr. Instrumentenk. Beibl. 16. p. 121, 1898.)—Parallel to each other in every way put two similar gratings on glass. Diffused light comes through these from a bright sheet

of white paper. The rays which come through clear glass areas in both gratings form groups, in each of which groups the rays are parallel to one another. Each such group is focussed by a lens so as to form a distinct band. Between these bands are dark areas, the light tending to reach which has been obstructed by one or other or both of the gratings. The eye on looking through the lens sees the further of the two gratings. The angular position of these bands is found to depend on the refractive index of the material between the grating surfaces, on their distance apart, and on the distances between the bars of the grating; whence an easy method of finding the refractive index of the glass on which the gratings are ruled. A. D.

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421. *Absorption of Light in a Magnetic Field.* **A. Righi.** (Comptes Rendus, 127. pp. 216–219, 1898.)—Assume a beam of white light to pass longitudinally along the axis of a Ruhmkorff electromagnet; polarise this by the first nicol, and let it be extinguished by the second. Between the poles is placed a sodium flame. As soon as the magnetic field is set up the flame will absorb radiations not of the same frequency as at first, but circularly polarised radiations of two frequencies respectively below and above the original frequency. This is the Zeeman phenomenon by absorption. Two residual circularly polarised radiations will thus reach the analyser; and one plane-polarised component of each will pass through. Accordingly there will not be extinction when the field is set up, but the passage of a yellow light resembling that absorbed by the sodium flame. These forecasts are confirmed by experiment. On turning the analyser the yellow light is not extinguished: it simply becomes whiter and brighter. A very strong original illumination will show this effect even with a magnetic field of 300 units, from one bichromate cell, lithium and thallium work as well as sodium, giving red and green light respectively. Hyponitric acid gas used instead of the sodium flame gives a green-blue, complementary, and with a complementary spectrum, to the yellow-red light transmitted by it; and on turning the analyser, the one colour changes into the other, without extinction, and the spectrum passes through a continuous condition into a complementary spectrum. This shows the emission spectrum of a non-luminous gas. Sodium vapour in hydrogen gas gives similar results. If the light pass exactly at right angles to the magnetic lines of force there is no effect. A. D.

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422. *Absorption in a Magnetic Field.* **A. Cotton.** (Comptes Rendus, 127. pp. 953–955, 1898.)—A beam of intense white light is made to traverse the following apparatus: (1) A nicol whose principal section makes an angle of 45° with the horizontal;

(2) an electromagnet giving a field of some thousands of units in which the lines of force are horizontal and exactly perpendicular to the beam; (3) a second nicol set almost at extinction with the first. The source is looked at across this nicol, and extinction is made complete. If a sodium flame of moderate brilliancy is now placed between the pole-pieces and the current started, the extinction is destroyed and a part of the original beam now traverses the second nicol; the source now sharply appears coloured yellow. On turning the second nicol through 45° so as to render its principal section vertical or horizontal, the same phenomenon is no longer observed: extinction once established persists when the field is set up.

This is an extension of an experiment of Righi, which was made in the same direction as the lines of force. The case is an application of the rule connecting together the emission and absorption for the same body, connecting the nature of the vibrations absorbed with the nature of the radiations emitted. When the beam is parallel to the lines of force, there is added to the phenomenon of Zeeman, which is a modification of the rays, Faraday's magnetic rotatory polarisation. This rotatory polarisation is particularly intense in the neighbourhood of the rays, as the experiments of Macaluso and Corbino show. It tends to destroy the original extinction. On making the experiment perpendicularly to the field its effects are removed, and those due to the Zeeman effect properly so-called are alone observed. J. J. S.

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423. *Zeeman Phenomenon.* **A. Righi.** (Roma R. Accad. Lincei Atti, 7. 1. pp. 295–301, 1898.)—Cornu has given an explanation (Journ. de Physique, Dec., 1897) which implies that for light emitted in the direction of the lines of magnetic force, every luminous ray becomes divided into two, circularly polarised in opposite senses, and that of these one has its period lengthened, one shortened, by the magnetic action. The difference between the Zeeman and the Faraday phenomenon would then be that in the former where the magnetic force acts on the luminous body, the velocity of propagation of the light remains unaffected though the period is changed: in the latter the period is unaffected but the velocities of propagation of the two components are altered. Airy showed that plane polarised light of N vibrations per second, passing through a Nicol's prism rotated n times per second round its own axis, may be considered as consisting of two opposite circularly polarised rays of frequencies, $N+n$ and $N-n$ respectively. Analogous results by other methods were described by the author in 1883 (Mem. R. Acc. Bologna, Jan. 14, 1883), and phenomena of interference between the two frequencies were also described at the same time, the fringes produced being not fixed but travelling athwart their length, after the manner of acoustical beats. It would be well if analogous experiments

could be made on the Zeeman light, but it appears not possible directly, since the two supposed rays come from natural light; but the following will show what conditions would be required to obtain the phenomena of beats. To represent natural light assume it to be elliptical, changing its form and axis rapidly, but yet slowly in comparison with the period of one complete vibration; in such a way that where $x=a\sin(2\pi Nt+\alpha)$ and $y=b\sin(2\pi Nt+\beta)$ represent the components at right angles to one another, we have the mean values of a^2 and b^2 equal to one another, and the analogous mean values of $ab\cos(\alpha+\beta)$ and of $ab\sin(\alpha-\beta)$ both $=0$. Putting $A^2=a^2+b^2+2ab\sin(\beta-\alpha)$; $B^2=a^2+b^2-2ab\sin(\beta-\alpha)$; $\tan\phi=(a\sin\alpha-b\sin\beta)\div(a\cos\alpha+b\sin\beta)$; $\tan\psi\ (=a\sin\alpha+b\cos\beta)\div(a\cos\alpha-b\sin\beta)$; we get

$$x=\tfrac{1}{2}A\sin(2\pi Nt+\phi)+\tfrac{1}{2}B\sin(2\pi Nt+\psi)$$
$$y=\tfrac{1}{2}A\cos(2\pi Nt+\phi)-\tfrac{1}{2}B\cos(2\pi Nt+\psi)$$

of which the first terms in each represent a circularly polarised ray and the second terms an opposite one.

On Cornu's hypothesis we would have to substitute for N in these respective circular rays the experimental values N_1 (right-handed) and N_2 (left-handed): and there would be a difference of phase such that

$$\tan(\psi-\phi)=\frac{2ab\cos(\alpha-\beta)}{a^2-b^2}$$

As this difference of phase varies with the four terms, direct interference experiments are not possible through establishing differences of path. But suppose a biprism to divide the light into two paths, and a pair of quarter-plates, one on each path, with their principal sections at right angles to one another, to convert the two circular rays in each of the two halves into two plane-polarised rays; the respective plane-polarised rays of the same frequency in the two bundles being then polarised in planes parallel to one another in space. Then the two bundles would be brought through a nicol with its principal section parallel to one of the two orthogonal planes of polarisation; and nothing would remain but a plane-polarised ray of frequency N_1 and another parallel to it of frequency N_2. These could interfere with one another, provided not only is $(\psi-\phi)$ constant, but also, as it turns out, that the mean values of a^2 and b^2 are not equal; that is that the light is not common light, but elliptically polarised light. And, further, the condition $(\psi-\phi)=const.$ itself implies circular polarisation, which becomes elliptical when the mean values of a^2 and b^2 are not equal; and to give zero intensities between the fringes the original light would have had to be plane-polarised. The experiment with shifting beat-fringes is therefore impossible with the light from Zeeman's tubes, but might be possible with the fluorescence light of certain crystals, which is said to be plane-polarised, though this light is probably consider-

ably too weak for the purpose. The effect of the magnet in Zeeman's experiment is equivalent to the addition to the vibration of a uniform rotation, right-handed, of frequency n per second, where N_1 and N_2 are respectively N_0+n and N_0-n. Hence, rotating the luminous body fast enough ought to have a similar effect to that of magnetisation: and the sense of the equivalent rotation would be right-handed round an axis parallel to the lines of force. A suggested consequence of this is that merely passing the light through an analyser would show fluctuations whose frequency was n. The reason why the effect is equivalent to an added right-handed rotation is that if in the expressions $x=\frac{1}{2}$ A sin $(2\pi N_1 t+\phi)$, $y=\frac{1}{2}$ A cos $(2\pi N_1 t+\phi)$ for Cornu's right-handed ray and $x=\frac{1}{2}$ B sin $(2\pi N_2 t+\psi)$, $y=-\frac{1}{2}$ B cos $(2\pi N_2 t+\psi)$ for his left-handed ray we put the values for A, B, ϕ, and ψ given above and bring together the components on the same axes, we get

$$2x=a \sin (2\pi N_1 t+\alpha)-b \cos (2\pi N_1 t+\beta)+a \sin (2\pi N_2 t+\alpha)+b \cos (2\pi N_2 t+\beta),$$

$$2y=a \cos (2\pi N_1 t+\alpha)+b \sin (2\pi N_1 t+\beta)-a \cos (2\pi N_2 t+\alpha)+b \sin (2\pi N_2 t+\beta);$$

and on making $N_1=N_0+n$ and $N_2=N_0-n$ these transform into

$$x=b \cos (2\pi nt) \sin (2\pi N_0 t+\alpha)+b \sin (2\pi nt) \sin (2\pi N_0 t+\beta),$$

$$y=a \sin (2\pi nt) \sin (2\pi N_0 t+\alpha+ b \cos (2\pi nt) \sin (2\pi N_0 t+\beta).$$

A. D.

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424. *Inverse Zeeman Effect.* **A. Righi.** (Comptes Rendus, 128. pp. 45–48, 1899.)—The author does not agree with the opinion of Macaluso and Corbino that the rotation of the plane of the vibrations is the principal cause of the appearance of light in the inverse Zeeman effect, for the condition favourable for the observation of rotation (great breadth of absorption bands) is not necessary, and is even prejudicial to the observation of Righi's effect. One consequence of the great breadth of band is that the light which is made to appear by exciting the magnetic field is no longer complementary to the light transmitted by the absorbing body, and a change of colour is observed which indicates at once the existence of a Zeeman effect. Such a change of colour is well observed in a column of nitrous acid 40 cm. long, and in thin layers of bromine and iodine. In all the above experiments the light is supposed to be parallel to the magnetic lines of force. E. E. F.

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425. *Light Traversing Metallic Vapours in a Magnetic Field.* **D. Macaluso** and **O. M. Corbino.** (Comptes Rendus, 127. pp. 548–551, 1898.)—A beam of sunlight polarised by a nicol

traverses the magnetic field produced by an electromagnet, then a second nicol and a cylindrical lens; it is then received on a Rowland's concave grating. The second diffraction spectrum is observed. If between the poles of the unexcited electromagnet a Bünsen flame charged with sodium vapour is placed, the two absorption rays may by suitable arrangements be made to become very wide: thus D_2 may have a width equal to $\frac{1}{4}$ of the distance between the two rays. On now closing the circuit and producing a field of the intensity of 4,000 to 5,000 c.g.s. units, there is seen on each side of the two D rays bands parallel to the D lines, alternately luminous and obscure, which are displaced when the analyser is turned, the axis of each ray following the sense of the current.

These bands appear to be due to light polarised in different planes, and the primitive plane of polarisation has undergone, in the passage of the light across the sodium vapour influenced by the field, a rotation increasing in a continuous manner from the exterior to the margin of the ray. This rotation, which commences to manifest itself for the ray D_2 at a distance of more than two-thirds of that between the two rays, increases continuously and rapidly on approaching the edge of the ray, where it attains 270°. The relative rotation, *i.e.*, the difference of the rotations corresponding to equal displacements in the spectrum, increases rapidly in proportion as the edge of the ray is approached.

Proceeding in the spectrum from points farther off to points nearer the ray, the rotation of the corresponding planes of polarisation to the right and to the left of it occurs in the sense of the magnetising current, and consequently is reversed with inversion of the field.

At points at an equal distance to the right and to the left of the ray the rotations of the plane of polarisation are equal. For the two D rays the ratio of the distances at which equal rotations are produced is almost equal to the ratio of the breadths of the primitive rays. Whilst on the margin of each of the D rays the rotation is constant, the distance of the point where the rotation commences is greater in proportion as the ray is broader, so that with the widening of this latter the relative rotation diminishes and the bands become broader.

In the case of rays little widened on their edges, it is found that circularly polarised light occurs followed by elliptically polarised light, in which the ratio of the axes rapidly tends to zero. With the widening of the rays the circular light completely disappears and the elliptic remains confined to the margin of the ray, whilst the rotation of the plane of polarisation extends much beyond the margin. Similar but less pronounced effects have been found in the case of lithium vapour.

On the hypothesis that the two inverse circular rays, into which the original beam may be supposed to be decomposed, are propagated with different velocities in the vapours of sodium and lithium under the influence of the field, and that the difference of

velocity diminishes rapidly with the increase of the difference between the period of the incident vibration and that of the absorbent value, the rotatory polarisation and the great rotatory dispersion observed may be explained. And on the hypothesis that for certain wave-lengths very little different from that of the ray, the absorbing power of the vapour for the two inverse circular rays may be different, the presence of circular and elliptic light on the edges of the ray may be explained. Both on the right and on the left of the ray the circular turning in the sense of the current would be propagated with a greater velocity, whilst on one side and on the other the circular in one sense and that in the opposite sense (conformably to the experiments of Zeeman) would be absorbed in preference.

(The explanation of the phenomena here described is discussed by M. Becquerel. See 1899, Abstract No. 246.) J. J. S.

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426. *Anomalous Dispersion and Magnetic Rotatory Power.* **H. Becquerel.** (Comptes Rendus, 127. pp. 899–904, 1898.)—Referring to his previous paper (see 1899, Abstract 246) the author describes the means which he has devised for verifying his hypothesis that the remarkably great rotatory power observed by Macaluso and Corbino in sodium vapour must be due to a phenomenon of anomalous dispersion. He has employed Kundt's arrangement, in which two prisms are crossed at right angles, one containing the absorbing substance. For this latter the author uses a flame containing the vapour of sodium or lithium and made to assume a prismatic form. Light from an electric arc is concentrated on a horizontal slit placed at the focus of a collimator; the parallel light then traverses the prismatic flame, then a lens, and afterwards forms an image of the slit at the vertical slit of a spectroscope with a Rowland's grating.

It is found that on each side of the rays D_1 and D_2 sodium vapour presents a very notable anomalous dispersion. The regions of the spectrum where the magnetic rotatory powers are many thousands of times greater than those of neighbouring portions, are equally the regions where the values of $\frac{dn}{d\lambda}$ become many thousands of times greater. It appears in accordance with the author's views previously expressed that the values of $\lambda \frac{dn}{d\lambda}$ give the relative values of the magnetic rotations for corresponding wave-lengths. J. J. S.

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427. *Metallic Vapours in a Magnetic Field.* **D. Macaluso and O. M. Corbino.** (Comptes Rendus, 127. pp. 951–953, 1898.)—The authors refer to their previous communication and Becquerel's paper on their experiments. (See 1899, Abstracts

Nos. 246 and 426). They criticise his theoretical explanation with regard to the expression $\lambda \frac{dn}{d\lambda}$ becoming infinitely great near the border of a ray of absorption. **H. Becquerel** maintains the explanation which he has given of the phenomenon, and thinks that the Italian authors do not appear to have an exact idea of the phenomenon of anomalous dispersion. J. J. S.

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428. *Magnetism and Gas Spectra.* **E. van Aubel.** (Journ. de Physique, 7. pp. 408–409, 1898.)—Spectra were obtained from a capillary-tube constriction in Geissler tubes, employing a large induction coil; the magnetic field was produced between cylindrical poles of an electromagnet with vertical bobbins carrying a current from 25 to 30 amperes. Chlorine (with a Leyden jar in circuit) shows the appearance of several new bright lines and the enfeeblement of others when the electromagnet was excited. Sulphur (with tube slightly heated beforehand) showed the band spectrum replaced by a brilliant line spectrum (and the Geissler tube, near the kathode, took up an apple-green fluorescence); much the same effect, as regards the change from bands to lines, as is produced by intercalating a Leyden jar in the circuit. Fluoride of silicon showed a complete change of the spectrum. The author attributes these effects to the influence of magnetisation on the electric resistance of the gas in the Geissler. A. D.

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429. *Röntgen Rays.* **G. Guglielmo.** (Roma R. Accad. Lincei Atti, 7. pp. 189–198, 1898.)—Discusses the molecular discharge and ether-displacement theories and concludes against the former for Röntgen rays, on the ground of the absorption being insufficient in amount. The want of diffraction and interference points to a want of periodicity. A. D.

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430. *Röntgen Ray Screens.* **P. Villard.** (Écl. Électr. 16. pp. 313–314, 1898.)—A barium platinocyanide screen, rendered non-responsive by prolonged exposure to Röntgen rays, may be revivified by exposure to sunlight. The ultra-violet, violet, and blue take hardly any part in this effect, the active rays in relation to which are three bands, respectively 900-710, 590–540, and 510-480 millionth mm. The third of these bands is the most effective. The first band is largely in the infra-red; the third hardly goes beyond the green. A. D.

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431. *Transformations of Röntgen Rays.* **D. Hurmuzescu.** (Écl. Électr. 16. pp. 314–315, 1898.)—The discharging effect of the secondary rays produced on impact of Röntgen rays bears no relation to the opacity of the body impinged upon, nor to the nature of the surrounding gas; but it does depend on the material of the electroscope cage. A. D.

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432. *Medical Application of Röntgen Rays.* **A. Remond** and **Noë.** (Écl. Électr. 16. pp. 315–316, 1898.)—Excitation of the tube unipolar-wise by a static electric machine gets rid of the painful feeling associated with the exploration of cavities of the human body by a Crookes tube excited from an induction coil. Putting the positive terminal of the machine to earth, as also the patient, the operator, and all the instruments employed, keeps the patient's body all at zero potential, and there is no discomfort. A. D.

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433. *Radiography.* **O. Murani.** (N. Cimento, 8. 4. pp. 112–116, 1898.) — A metallic reflector is good when used immediately behind a photographic film; but it is of no use and is not required when a glass plate is used. In that case the glass itself acts as the reflector would do. **Malagoli** and **Bonacini** (ibid., pp. 97–102) say the metallic backing is necessary in all cases, even with glass plates, the more so the harder the tube, and especially so with focus-tubes; else there is fogging and want of contrasts. But it is less necessary with glass plates than with films; and with very soft pear-shaped Crookes tubes, which require long exposures, the advantage of using a metallic backing may disappear. A. D.

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434. *Röntgen Ray Shadows.* **E. Villari.** (Roma R. Accad. Lincei Atti, 7. 1. pp. 291–295, 1898.)—The shadow of a body which intercepts the radiations from a focus tube is bounded by a comparatively clear border some millimetres wide, a species of penumbra; this terminates abruptly exteriorly but degrades rapidly towards the centre of the shadow. If the tube used be a Crookes of pear shape, the shadow has a well-defined boundary. Near this boundary, within the shadow, is a black fringe; outside the boundary is a pale penumbra, fading away towards the exterior, some millimetres wide, which is followed by a very bright fringe, and this by the less bright region of full action of the rays upon the plate. The full central shadow seems to darken gradually from periphery to centre, by reason of a probable extensive flexion of the Röntgen rays in the umbral region between the intercepting body and the sensitive plate. A. D.

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435. *Discharge by Röntgen Rays.* **E. Villari.** (Roma R. Accad. Lincei Atti, 7. pp. 261–272, 1898.)—Detailed experimental paper. The discharge of an electroscope by Röntgen rays is due to the air set in activity by these. An electroscope is thus discharged even in the full shadow of an obstacle, through the diffusion of this air. A tube of glass or zinc which suppresses laterally divergent rays slows down the discharge very much; and if the lateral active air be prevented from reaching the electroscope, again the discharge is slowed down; and the narrower the tube used the less is the discharging effect, because the smaller is the quantity of air rendered active. The discharge takes place though a protecting cover of aluminium or card be applied to the electroscope, as if the rays were bent round; but lead stops the action. On surrounding the ball of the electroscope with an insulated zinc tube, the effect of the Röntgen rays passed along the zinc tube is suddenly to discharge the outer induced charge on the zinc tube. This causes an apparent sudden partial discharge of the electroscope; and the gradual discharge by means of the air follows after this. The sudden apparent discharge can be imitated by discharging the outer induced charge by means of a flame. If the tube be of paraffin the opposite charge comes partly to the outside. If the paraffin be a solid block, there is no air, and the latter part of the phenomenon—the gradual discharge—is absent.

A. D.

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436. *Röntgen Rays and High Temperatures.* **A. Volta.** (N. Cimento, 8. 4. pp. 241–255, 1898.)—A flame in the path of Röntgen rays does not appreciably affect their transmission, even in the presence of metallic vapours. Elevation of temperature increases, in platinum, steatite, and carbon, the actinic energy of their secondary radiations; especially in carbon, which, brought to incandescence, acts as an opaque body. For brass, zinc, tin, aluminium, microscopic cover-glasses, the penetration by secondary rays is not much affected by changes in temperature; but it is small, so that even thicknesses as small as 1 mm. will cause pretty complete absorption. The apparent transparence, as made out from the shadows, diminishes upon the heating; but this effect is small and sometimes uncertain. A. D.

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437. *Duration of Röntgen Radiation.* **H. Morize.** (Comptes Rendus, 127. pp. 546 548, 1898.)—By a toothed-wheel method it is found that to each passage of current in the primary coil correspond several partial discharges in the tube. The total Röntgen radiation lasting 0·00109 second, each partial discharge takes 0·000082 sec., and the intervals between the partial discharges are all equal to 0·00033 sec. A. D.

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438. *Fluorescence in Crookes Tubes.* **P. Villard.** (Écl. Électr. 16. p. 313, 1898.)—While the cross is forming its shadow in a Crookes tube, suddenly remove it from the path of the radiation. The place of the shadow is taken by a comparatively bright cross, which quickly disappears, leaving a uniform fluorescence. The shadow was comparatively cool and therefore more fluorescent than the glass already heated by the discharge; but the conditions soon become uniform. Direct experiments by local heating or cooling confirm this. Oxide of zinc fluoresces green when cold, violet when hot; sulphide of zinc, bluish and green respectively; chalk, orange to bright yellow. Perhaps glass which does not appear at all fluorescent when it is very hot, really gives out invisible radiations. A. D

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439. *Phosphorescence.* **H. Jackson.** (Phil. Mag. 46. pp. 402–414, 1898.) — This paper was given as a lecture at the British Association meeting at Bristol, and in it the attempt has been made to connect together all the phenomena of phosphorescence, with a view of showing between them a likeness in kind. It is suggested that all these phenomena may be looked upon as outward evidences of response on the part of the substances to rapid oscillations, whether these oscillations have their origin in chemical combination, in what is commonly spoken of as light, or in electrical discharge. The nature of that response may in some cases be of a direct character; but when account is taken of the many degrees of persistence of phosphorescence and of potential phosphorescence, it seems in many cases first to assume the form of something which may be called a statical charge. The release of this condition of strain is accompanied by oscillations which give rise to the visible undulations of the phosphorescent light. J. J. S.

HEAT.

440. *Thermal Conductivities of Glass.* **T. M. Focke.** (Wied. Annalen, 67. 1. pp. 132–159, 1899.)—The specific thermal conductivities of the ordinary constitutents of glass are tabulated as follows:—

MgO	$3{\cdot}71+10^3$	BaO	$1{\cdot}25$	Na_2O	$0{\cdot}70$
SiO_2	$3{\cdot}15$	PCO	$1{\cdot}24$	K_2O	$0{\cdot}59$
Al_2O_3	$2{\cdot}58$	ZnO	$1{\cdot}20$	Sb_2O_3	$0{\cdot}28$
S_2O_5	$2{\cdot}34$	CaO	$0{\cdot}94$	As_2O_5	$13{\cdot}1$
B_2O_3	$2{\cdot}00$				

When the conductivities of the various glasses are then determined from the weights of the constituents and the above values, the agreement is within 1·6 per cent. on the average.

The determinations of conductivities were made by Venske's method. E. E. F.

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441. *Thermal Conductivities of Glass.* **A. Winkelmann.** (Wied. Annalen, 67. 1. pp. 160–164, 1899.)—The thermal conductivity of glass may be calculated from the volumes of the various chemical constitutents in the vitreous state, as known from their weights and densities. The author gives a method of doing this in which he supposes that the various constituents form separate layers of proportionate thickness, arranged in planes at right angles to the propagation of heat. This conception leads to a simple theory, and the calculated values agree with the observed ones, to within 5 per cent. at all events.

E. E. F.

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442. *Linear Expansion.* **Vandevyver.** (Journ. de Physique, 7. pp. 409–414, 1898.)—Apparatus, based on the use of a spherometer, for measuring the thermal linear expansion of bars.

A. D.

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443. *Temperatures in a Linear Bimetallic Conductor.* **P. Straneo.** (Roma R. Accad. Lincei Atti, 7. pp. 206–213, 1898.)—A mathematical investigation into the equations of condition during the variable state of the temperatures, in the most general case and also with superimposed limitations.

A. D.

SOUND.

444. *Vibrations of Plates.* **J. Zenneck.** (Wied. Annalen, 67. 1. pp. 165–184, 1899.)—The author endeavours to formulate a theory which includes the vibrations of such circular plates as are not perfectly symmetrical and homogeneous. He shows that of all the points in which any vibration could take place, those in which it actually does take place are distinguished in such a manner that for them the frequency is either a maximum or a minimum. E. E. F.

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445. *Vibrations of Pipes.* **A. Appunn.** (Wied. Annalen, 67. 1. pp. 217–221, 1899.)—Since the attacks made upon the accuracy of the pitches indicated on the author's standard pipes, he has verified these pitches by closing the pipes with small mica plates, which are stiff and elastic, and photographing the spot of light produced by these plates when they reflect a beam of sunlight. When analysed by a revolving mirror, the spot makes a series of dots and intervals expressing the vibrations of the air column. On counting the spots corresponding to a known interval of time, he found that the ratios had been indicated correctly, and that even the highest pitch, 56,000 per second, was correct to within a few hundred vibrations. E. E. F.

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446. *Difference Tones.* **A. Appunn.** (Wied. Annalen, 67. 1. pp. 222–226, 1899.)—In reply to the criticism of Melde and Stumpf and Meyer, the author maintains that difference tones cannot be successfully used to determine high pitches, on account of the great difficulty of distinguishing between the various orders of difference tones. Especially at the high pitches, the third difference tone is often the most audible. Thus in comparing a pipe having a pitch of 24,000 per second with one of 8,000 per second, the difference tones are 16,000 and 8,000 respectively. The latter being the stronger, the pitch is found to be $8{,}000 + 8{,}000 = 16{,}000$, instead of 24,000. In case of the pipe of pitch 50,000, the same method also gives 16,000, as 8,000 is the pitch of the third difference tone, and is the loudest of the three. E. E. F.

ELECTRICITY.

447. *Wimshurst Machines.* **S. Leduc.** (Écl. Electr. 16. pp. 309–311, 1898.)—These machines work even without points, but the glow, as seen in the dark, is differently distributed. The starting-point is a contact E.M.F. between a metallic sector and the brush; and the opposed brushes form a condenser, the dielectric in which is the two plates and the space between them. Much of the charge on the metallic sectors is lost by discharge into the air before reaching the collectors; and the efficiency can be increased by adjusting the collectors so that they collect the charges on the metallic sectors immediately these charges become free through the withdrawal of the opposite sectors. A. D.

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448. *Adjustable Leyden Jars.* **S. Leduc.** (Écl. Électr. 16. pp. 311–312, 1898.)—The author makes the inner coating a metal-surfaced cylinder with hemispherical ends which can slide up and down. The outer coating covers only the lower part of the jar. Such Leyden jars are suitable for the author's method of exciting a Röntgen ray tube by fitting it between the outer coatings of two Leyden jars suspended on the two terminals of a frictional electric machine, the kathode being connected with the jar suspended on the positive terminal; a shunt being provided by means of a chain from each outer coating, with its free end lying on a board. The objection to this method, that the discharges are intermittent, is removed by sufficiently reducing the capacity of the Leyden jars; and if these adjustable Leyden jars are used, the tube should be connected with the movable inner coatings so as to avoid sparks. With Leduc's modified Wimshurst collectors and these Leyden jars a 22 to 24-inch Wimshurst gives results equivalent to those of a 6 to 8-inch spark induction coil, and the tubes are better treated under this method. A. D.

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449. *Electricity and Fog.* **A. Garbasso.** (N. Cimento, S. 4. p. 265, 1898.)—The fog-dispersing effect of an electric charge is due to the charged surface rather than to the field; for if the former be covered with a glass tube, even though this be pierced with extremely small holes, there is no effect. A. D.

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450. *Velocity of Particles in Discharge by Ultra-violet Light.* **H. Buisson.** (Comptes Rendus, 127. pp. 224–226, 1898.)—The uniform potential slope between the plates of a condenser is disturbed by ultra-violet light, which produces a discharge of the

condenser; there is during the discharge free electricity in the air, the density is not null, nor ΔV, which becomes $\delta^2V/\delta x^2$, and the potential line is a curve, nearly parabolic. The positive plate loses no charge: the charge of the negative plate is carried over to it. The air does not take any active part in the discharge. The density is found from $\delta^2V/\delta x^2 = -4\pi\rho$ and the velocity v of the charged particles under density ρ, transversing section s of flux, and current strength i, from $i = v\rho s$. Integrating the former we get $V = V_1 x + 2\pi\rho x\ (d-x)$, of which the latter term can easily be measured differentially and ρ found. This gives v. The velocity v is independent of the intensity of the light employed, and is approximately proportional to the field: 25 cm./sec. at 10 volts/cm., and 135 cm./sec. at 60 volts/cm. Righi found higher velocities, but he used powerful fields from an electrostatic machine, about 30,000 volts apparently. A. D.

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451. *Electric Sparks.* **S. Leduc.** (Écl. Électr. 16. pp. 312–313, 1898.)—Taking sparks between a sphere brought into contact with the film side of a photographic plate, and a tinfoil backing, the image on development is very sharply defined, without fog, and differs according to the direction; and the spark area is broadened by increase of potential, but narrowed by increase of quantity. As the air-pressure is diminished the image becomes more and more blurred, and at 1 to 2 cm. Hg there is complete fogging. The spark image is different in different gases. In alcohol (covered by CO_2 gas) there is no luminous effect, but the plate is fogged. Dusting the plate with various substances alters the result and makes the differences smaller between positive and negative discharges. When both terminals are brought into contact with the same photographic film, the image of the discharge is different at its two ends, which points away from the idea that the transport of matter is in one direction only. A. D.

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452. *Point-Discharges.* **E. Warburg.** (Berlin Akad. Sitzber. 17. pp. 236–242, 1898.)—When a point is placed opposite a metallic surface which is connected through a galvanometer to earth, and the point brought to a potential which exceeds a certain limit, the galvanometer indicates a constant current, which is carried from the point to the metallic surface by the intervening air. The air has thus acquired conductivity; and the author finds that it fully acquires this conductivity in 0·007 second after the point has been charged. Probably, though not yet certainly, this is a true conductivity of the whole air between the point and the plate, and the electric wind is a secondary phenomenon. A. D.

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453. *Point-Discharges.* **E. Warburg.** (Wied. Annalen, 67. 1. pp. 69–83, 1899.)—If a point P is kept in a constant absolute potential V, and is mounted opposite an infinite metallic plane at a distance D, the density of the current traversing the air between the point and the plate is at any point Q—

$$i = \frac{a}{D^n} V\,(V - M)\cos^m \theta$$

where $\theta < 60°$, and denotes the angle between P Q and the normal, while a and M are positive constants depending upon the nature of the point, $n = 3{\cdot}17$, and $m = 4{\cdot}65$ for negative potentials and $4{\cdot}82$ for positive potentials. E. E. F.

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454. *Kathode Rays.* **P. Villard.** (Comptes Rendus, 127. pp. 223–224, 1898.)—A paper upon the fluorescence observed in a focus tube and attributed by S. P. Thompson to *parakathode* rays from the point of impact of the kathode rays, sensitive to electric and magnetic fields, but not capable of originating Röntgen rays. The author holds they do produce Röntgen rays, and are genuine kathode rays which may be provisionally considered as arising from diffusion of the primary kathode rays—diffusion which presents a maximum of intensity in a direction not very different from that which would be taken by regularly reflected rays. The result is the same whether the antikathode be isolated or an anode. On impinging on the antikathode the particles of electrified hydrogen diffuse most readily into the weaker parts of the field. A. D.

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455. *Magnetic Deflection of Reflected Kathode Rays.* **E. Merritt.** (Phys. Rev. 7. pp. 217–224, 1898.) — Apparatus arranged to observe the behaviour of direct and reflected rays at the same time, and under the same conditions (vacuum, mode of excitation, &c.) : the reflected rays being those from platinum. There was no difference between the deflections of the direct and the reflected rays unless the deflecting magnet came so near as to distort the kathode rays between the kathode and the reflector. This would indicate, on the Crookes theory, that the velocity of the particles is not appreciably altered by reflection ; and probably the particles are reflected not by the platinum surface as a whole, but by individual particles of platinum. The behaviour of these might be expected to affect the result. A. D.

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456. *Kathode and Lenard Rays.* **E. Goldstein.** (Wied. Annalen, 67. 1. pp. 84–94, 1899.)—The author primarily investigates the light of the third kathode layer, called by him K_3 rays.

He first surmised that they were formed by the reflection of the light of the second layer, the K_2 rays. But a further investigation has shown that the K_3 rays proceed in straight lines from every point of the space filled by the K_2 rays. While a solid immersed in K_1 or K_2 rays casts a shadow, it does not do so when immersed in K_3 rays, unless it is broader than the incident K_2 bundle. The well-known fact that kathode rays, when impinging upon a solid substance, give rise to other rays proceeding in all directions as in diffused reflection, is amplified by the author into the statement that these rays give rise to secondary rays both when they impinge upon a solid wall and when they impinge upon gaseous molecules. Hence the origin of the K_3 rays. The latter again appear to undergo a similar process of conversion when impinging upon ponderable matter, but the quaternary rays are very feeble and barely perceptible. When the solid wall is very thin, the incident rays are partly reflected and partly transmitted. The transmitted portion constitutes the Lenard rays.

E. E. F.

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457. *Coherers.* **A. Blondel.** (Écl. Électr. 16. pp. 316–317, 1898.)—The condition of success appears to be that the filings should not be too conductive nor yet coated with too thick a film of oxide. Silver does not work; but if exposed to sulphuretted hydrogen it works better and better up to a certain point, and then as the film of sulphide thickens the efficiency falls off.

A. D.

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458. *Coherer-Sparks.* **R. Malagoli.** (N. Cimento, 8. 4. pp. 109–111, 1898.)—By photographic methods it is found that in the metallic powder coherer the variation of resistance produced by the electric waves is accompanied by sparks from particle to particle of the powder. In order to enable photographic results to be produced the electrodes must be of suitable dimensions. Coherers may be regarded as resonators in which the impact of suitable electric waves reduces the resistance in the dielectric.

A. D.

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459. *Velocity of Hertzian Waves in Dielectromagnetic Media.* **V. Boccara** and **A. Gandolfi.** (N. Cimento, 8. 4. pp. 191–215, 1898.)—Media made up of a paste of paraffin and iron powder are both dielectric and have definite magnetic permeabilities. The magnetic permeability μ, the specific inductive capacity K, and the index of refraction for Hertzian waves go on increasing as the proportion of iron is increased. The values of this index of refraction are in concord with the theoretical value $\sqrt{K\mu}$.

A. D.

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460. *"Antennæ" in Wireless Telegraphy.* **A. Blondel.** (Écl. Électr. 16. p. 316 and p. 318, 1898.) The author thinks the action of these depends on their capacity as forming along with the earth a condenser, the seat of an oscillating discharge at the moment when the primary circuit is broken; and the receiving antennæ become the seat of a displacement current which acts on the coherer. **A. Broca** (Écl. Électr. 16. p. 318) notes that the flux of energy (analogous to that in polarised light) passes through zero values, and that it is also along the wire and is indeterminate in direction at the end of the wires in a plane normal to the axis of the antennæ: so that it is concentrated on a particular plane instead of being sent in all directions. The fact that it is polarised tends towards null values as we leave this plane.

A. D.

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461. *Short-circuited Secondary Coil.* **J. H. Smith.** (Phys. Rev. 7. pp. 231–235, 1898.)—The author investigates the effect of a short-circuited secondary coil of small resistance upon the oscillatory discharge of a condenser in the primary circuit. It is shown mathematically that in certain cases the period of oscillation in the primary circuit is diminished, and the result is confirmed by the experiments of Hotchkiss and Millis with the Hotchkiss galvanometer, in which the natural period of the vibration in a circuit is diminished by bringing a solid brass cylinder near the circuit.

J. L. H.

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462. *Electric Currents in Dielectric Liquids.* **A. Naccari.** (N. Cimento, 8. 4. pp. 259–260, 1898.)—In dielectric liquids Ohm's law is obeyed, and the specific resistance does not vary with the electromotive force. It was also found that there is no variation of the resistivity with the area of the opposed electrodes.

A. D.

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463. *Dielectric Constants and Temperature.* **H. Pellat** and **P. Sacerdote.** (Comptes Rendus, 127. pp. 544–546, 1898.)—The dielectric constant of paraffin diminishes as the temperature rises; $3{\cdot}6\times10^{-4}$ per °C. between 11° and 22°, and $5{\cdot}6\times10^{-4}$ between 11° and 33°. That of ebonite rises; mean, $8{\cdot}8\times10^{-4}$ between 10°·4 and 20°·6. Consequently, taking previous results (Pellat, Journ. de Physique, 3rd series, vol. 7. p. 18), that to charge a condenser at a constant temperature takes not $CV^2/2$ but $CV^2/2.\{1+T(\lambda+\chi)\}$, where T is the absolute temperature, λ the coefficient of linear dilatation, and χ the variation in the dielectric constant per °C., for an ebonite condenser the term $T(\lambda+\chi)$ has at 27° C. the value 0·29, and the capacity of such a condenser is 29 per cent. greater than has been supposed. If the charging be rapid, it is not isothermal but adiabatic, and

$0{\cdot}29 \times CV^2/2$ ergs of heat are transformed, causing cooling: and on sudden discharge the same quantity is liberated, causing heating of the condenser. For an ebonite condenser of 2 mm., charged to a potential difference corresponding to 1 cm. spark, the heating or cooling would be a little less than $0°{\cdot}001$; but this is masked by the residual phenomena. A. D.

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464. *Dielectric Constant of Stretched Glass.* **G. Ercolini.** (Roma R. Accad. Lincei Atti, 7. pp. 172–177 and 183–189, 1898.)—By the aid of the "principle of the conservation of electricity," Lippmann has shown, theoretically, that, in general, if a dielectric is stretched, the specific inductive capacity when the lines of force run at right angles to the length is increased by an amount proportional to the load. Dessau confirmed Lippmann's conclusion, qualitatively; but Corbino experimenting on glass found that the specific inductive capacity *diminished*. Maxwell stated that the square of the refractive index, under certain conditions, should equal the dielectric constant. Now, when a plate of glass is stretched it behaves exactly like a positive crystal, with the axis parallel to the direction of tension. Moreover, Fresnel noticed that in stretched glass the ordinary index of refraction is less than the original index, and Kerr has proved that the ordinary index diminishes with tension, whilst the extraordinary does not alter, so that Corbino surmises that the dielectric constant ought to diminish in a direction perpendicular to the tension. The author mentions a multitude of reasons why the relationship indicated by Maxwell should have no bearing on the present question; he also criticises Corbino's method of experimenting and states that the experiments lead to no decisive results.

The second part of the author's work contains a description of apparatus and experiments, which show that the dielectric constant of glass is *increased* by tension. A. Gs.

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465. *Electric Properties of Ammonia.* **H. M. Goodwin** and **M. K. Thompson, jun.** (Phys. Rev. 8. pp. 38–48, 1899.)—The dielectric constant of liquid ammonia is determined by Drude's second method. A small condenser containing liquid ammonia at $-34°$ C. is introduced into the secondary circuit of a small condenser, and the length of the circuit for maximum resonance is noted. The same dielectric constant is then produced by mixing benzene with water and acetone. The mean value of the dielectric constant of various specimens of ammonia is 22, being nearly that of ethyl alcohol and of acetone. As regards conductivity, the authors have made determinations for temperatures ranging from $-13°$ C. to $-29°$ C. (under pressure).

At the former temperature it is 1·688, at the latter $1{\cdot}392 \times 10^4$. The mean temperature coefficient of the conductivity is therefore $0{\cdot}018 \times 10^4$. The molecular conductivity of silver nitrate dissolved in liquid ammonia is greater than when it is dissolved in water. This points to a high degree of dissociation of the dissolved salt, and that assumption is confirmed by the fact that at high dilutions ($V = 100$) the molecular conductivity approaches a limiting value. E. E. F.

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466. *Electrolytic Polarisation under Varying Pressures.* **R. Federico.** (N. Cimento, 8. 4. pp. 145–191, 1898.)—At constant pressure, the E.M.F. of polarisation rises rapidly for a short time (about the first second) and then slowly comes up to a maximum value. Apart from the initial rise, the gradual increase is nearly proportional to the time of closure of the circuit; and after about a minute the curve is like a branch of an equilateral hyperbola. The maximum value reached by the E.M.F. of polarisation itself rises with the pressure, more rapidly under low than under high pressures. A. D.

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467. *Measurement of Small Inductances.* **H. Martienssen.** (Wied. Annalen, 67. 1. pp. 95–104, 1899.)—The author measures small inductances by the displacements of phase which they produce in an alternate current. He uses an apparatus capable of indicating phase differences down to 1 sec. of arc. It is based upon the following principle: If two branches of a circuit of resistances R_1 and R_2 and inductances L_1 and L_2 are traversed by a sinusoidal alternating current, the numerical phase difference ϕ is given by the equations:—

$$\phi = \phi_1 - \phi_2$$

where—

$$\tan \phi^1 = \frac{\omega L_1}{R_1} \quad \tan \phi_2 = \frac{\omega L_2}{R_2}$$

and—

$$\omega = \frac{2\pi}{T} = \text{the frequency.}$$

If ϕ is small, this relation holds good for any alternating current whatever, and also—

$$\tan \varphi = \phi = \omega\theta$$

where θ is the phase difference in time. Hence

$$\theta = \frac{L_1}{R_1} - \frac{L_2}{R_2}$$

Hence L_1 can be determined if θ is measured and L_2 is known, or L_2 can be determined by varying R_2.

In the actual apparatus the inductance is measured by the torsion exerted upon a metallic cylinder in a rotary field as a consequence of the phase difference of two currents. The same apparatus can also be used for measuring capacities. E. E. F.

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468. *Magnetic Deflection of Electric Discharge.* **J. Henry.** (Phil. Mag. 46. pp. 429–452, 1898.)—This deflection, by a magnetic force at right angles to the direction of discharge, is like that which a flexible and elastic conducting string would undergo if it carried a current in the same direction as that in which the discharge passes through the gas (J. J. Thomson, "Rec. Res." p. 131, par. 127). By photographic methods the author found the amount of the deflection to vary from gas to gas in the following decreasing order: H; Cl (?); N, O, Air; NO; Br (?); CO; NH_3; CO_2; SO_2 (?). The discharge is also bent or distorted by convection-currents; more so at high than at low gas-pressures: and at very high gas-pressures there is no steady position such as is assumed by the discharge at lower pressures. In hydrogen this distortion was almost imperceptible. There is very little, if any, change of deflection with pressure so long as the current in the discharge is kept constant; the deflection increases with the current in any case, but is independent of the potential-difference. Apparently the discharge follows the lines of least resistance along a chain of ionised particles, which chain is itself deflected: but if the chain or thread be dissipated or destroyed before the next discharge comes, the discharge is then direct, there being no deflection unless each discharge lasts a sensible time. If it do so last, the discharge is broadened, low pressures being necessary in order to bring about this result. The maximum current in the discharge was not at all proportional to the average current: with increasing pressures the former increased, the latter decreased. The quantity of electricity carried by each discharge is of little importance. The kind of gas determines the rate at which the chains or threads of ionised particles are broken up by diffusion so as to tend to make the path of least resistance the shortest one; or by the recombination of the ions; or by the actual travel of the ions towards the electrodes; and it determines the duration of the discharge and also the relative conductivity of the affected path after any given discharge. In mercury vapour (monatomic) the ionising effect of a discharge and the corresponding amount of deflection are small, apparently even less than in hydrogen. Experiments were also made in blowing the discharge in a rarefied gas; the mechanical deflection produced thereby was small in hydrogen, considerable in air; and the magnetic and mechanical deflections are affected by the nature of the gas in exactly the same way. A. D.

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469. *Electrolytes in a Magnetic Field.* **H. Bagard.** (Comptes Rendus, 128. pp. 91–94, 1899.)—While admitting that the specific resistance of electrolytes does not vary in a magnetic field, the author maintains that the resistance of any given liquid conductor is modified by the presence of such a field, and he describes his method of bringing it clearly into evidence. The liquid conductor is a ring of $CuSO_4$ solution contained in a circular glass tube of rectangular cross section. This ring is placed between the poles of an electromagnet so that the lines of force are parallel to the axis of the ring. The latter is interrupted for a short length, and tubes containing more liquid, and serving as terminals, are fused on side by side. On establishing a field of some 5,000 units, the galvanometer indicates an abrupt change of resistance amounting to about 1 per cent. in the case of a ring 4.4 cm. wide, and about 1 sq. cm. in sectional area, and when the current flows in such a direction that the magnetic lines of force would tend to narrow the circle. It is rather more than that when the force is such as would tend, by Ampere's rule, to widen the circle. The author accounts for the effect by supposing that the magnetic field has a definite effect upon the flux of the current in the liquid. E. E. F.

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470. *Magnetic Susceptibility of Liquid Oxygen.* **J. A. Fleming** and **J. Dewar.** (Roy. Soc. Proc. 63. pp. 311–329, 1898.)—The authors describe an investigation of the magnetic behaviour of liquid oxygen under magnetic forces ranging from 500 to 2,500 c.g.s. units. The principle of the method used by the authors is the well-known fact that if a body, either para- or dia-magnetic, be placed in a magnetic field of variable strength, it is subjected to a force acting in the direction in which the field varies most rapidly. The field is provided by a vertical electromagnet, above the upper pole of which is suspended from one arm of a delicate balance a small sphere of a slightly para- or dia-magnetic material. The diameters of the spheres varied from about 1 to about 3 cms., and the materials used were silver, copper, bismuth, and glass. In each case a measurement was made of the magnetic susceptibility in air of the sphere used, by weighing it in a known magnetic field, and observing the loss or gain in weight (the actual field distribution was determined by a ballistic method, using a small exploring coil). The spheres were then weighed when immersed in liquid oxygen contained in a vacuum vessel placed above the pole of the magnet, and the loss in weight was determined when the exciting current was switched on. The mean value of the susceptibility, obtained from 36 determinations, is 324×10^{-6}, and hence the corresponding value of μ is 1·0041. The experiments show clearly that the susceptibility tends to decrease somewhat in strong fields. A comparison of the above value of the susceptibility with that of gaseous oxygen ($0{\cdot}13 \times 10^{-6}$) confirms the view that the susceptibility varies directly as the density and inversely as the absolute temperature. A. H.

471. *Magnetic Susceptibilities.* **E. Seckelson.** (Wied. Annalen, 67. 1. pp. 37–68, 1899.)—The magnetic susceptibilities of iron, cobalt, nickel, manganese, and platinum were examined by Quincke's method, in which a straight wire of the metal is hung by a bifilar suspension, and one of its ends is introduced between the poles of an electromagnet. That end is attracted into the field with a force depending in a certain manner upon the susceptibility of the material, and the consequent displacement of the other end is read by means of a microscope. The author examined electro deposits of the metals named on copper wires, and found that for all directions of the lines of force the susceptibility is greatest in iron, and that the other metals follow in the succession cobalt, nickel, manganese, and platinum. He also found that the susceptibility normal to the magnetic lines of force does not vary with the field, but that it diminishes in increasing fields parallel to the lines of force. The former susceptibility falls with increasing sectional area, the latter does the same after first passing through a maximum. The magnetic force across the lines of force increases as the square of the field. With the stronger fields the force along the lines of force increases simply as the field. E. E. F.

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472. *Fall of Magnetisation in Soft Iron.* **Lagrange.** (Paris, Soc. Franç. Phys. Bull. 118. p. 1, 1898.)—Displacement of fluorescent spot in a Crookes tube arranged in an electromagnetic field; when the electromagnet-exciting current is shut off the spot begins to return to its previous position, at first rapidly, then more and more slowly. The form of the curve of return is studied by means of a rotating mirror. A. D.

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473. *Eddy Currents and Hysteresis.* **A. Grau.** (Wien Akad. Sitzber. 107. pp. 495–505, 1898.)—The loss of energy through eddy currents in a mass of iron is ascertained, and by subtracting this as well as the amount dissipated through heating according to Joule's formula, from the total loss, the amount of work dissipated in hysteresis is obtained. The iron used was formed into rings of the same mass and of diameters 1, 2, and 3 mm., which were made the cores of transformers wound with copper wire through which an alternating current was sent. J. J. S.

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474. *Magnetic and Geodetic Observations in Madagascar.* **P. Colin.** (Comptes Rendus, 127. pp. 708–711, 1898.)—The author has determined the difference in longitude between a number of places in Madagascar by means of telegraphic signals,

also the latitude. Determinations of the three magnetic elements were made at three stations and gave the following results :—

Station.	Date.	Lat., S.	Long. E. of Paris.	Height above sea level.	Dec., W.	Dip.	Horizontal force.
Ankazobé..	Aug. 8, 1897	18° 19′ 29″	44° 45′ 25″	1243 m	11° 32′ 10″	54° 2′ 35″	0·21146
Andriba ..	Aug. 22, 1897	17° 34′ 34″	44° 32′ 30″	653 m	11° 9′ 42″	52° 20′ 19″	0·20547
Vohilena ..	Sept. 12, 1897	18° 8′ 1″	45° 15′ 23″	1329 m	10° 40′ 12″	53° 39′ 58″	0·21307

W. W.

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475. *Magnetic Charts.* **E. Mathias.** (Journ. de Physique, 7. pp. 455–461, 1898.)—The author proposes, at any rate for magnetic charts of comparatively small portions of the earth's surface, to represent the *difference* between the magnetic element at the different points on the chart and its value at some fixed magnetic observatory within the district, instead of the actual values of the element. The advantage claimed for this method is that the secular change of such differences is much smaller than the secular change of the elements itself, so that the chart can be used for a number of years with less chance of error, the values at the place considered being obtained by adding the quantity given by the chart to the value of the element for the time considered as obtained at the observatory. W. W.

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476. *Magnetic Elements on Jan.* 1, 1899. **T. Moureaux.** (Comptes Rendus, 128. pp. 94–95, 1899.)—The magnetic elements are given for Parc Saint-Maur, Perpignan, and Nice. For Parc Saint-Maur, situated at Long. 0° 9′ 23″ E Paris and Lat. 48° 48′ 34″ N, they are the following :—

	Absolute Values Jan. 1, 1899.	Secular Variation during 1898.
Declination	14° 51·45′	−4·60′
Dip	64° 57·5′	−1·4′
Horizontal force	0·19682	+0·00022
Vertical force	0·42127	+0·00002
Total force	0·46498	+0·0011

The values for Jan. 1st are the means of all the hourly values for Dec. 31st and Jan. 1st. E. E. F.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

477. *Free Hydrogen in Atmospheric Air.* **A. Gautier.** (Comptes Rendus, 127. pp. 693–694, 1898.)—Atmospheric air contains minute quantities of combustible carbonaceous gases, derived from the earth or from combustion. The air of mountains or of the sea is nearly free from them, but always contains a small but very constant amount of hydrogen, from 11 to 18 c.c. per 100 litres being found. T. E.

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478. *Diffusion through Ferrocyanide Membranes.* **A. Naccari.** (N. Cimento, 8. 4. pp. 260–261, 1898.)—For a given membrane, the substances blocked by it have higher molecular weights than those which pass through. Generally (aniline being an exception) the lower the molecular weight the higher the velocity of passage, but the product of the $(\text{velocity})^2$ into the molecular weight is not constant; for the velocities at low molecular weights are proportionately higher than this would indicate. A. D.

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479. *Cryoscopic Solvents.* **F. Garelli.** (Roma R. Accad. Lincei Atti, 7. 2. pp. 27–34, 1898.)—The author recommends the use of stannic bromide as a solvent for solid solutions, and gives detailed results of its use with $C_2H_4Br_2$, $C_2H_4Cl_2$, $CHBr_3$, CBr_4, &c. A. D.

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480. *Osmotic Pressure in Ether Solutions.* **H. M. Goodwin** and **G. K. Burgess.** (Phys. Rev. 7. pp. 171–187, 1898.)—The authors describe measurements of the vapour pressure of ethereal solutions of naphthalene, benzophenone, and diphenylamine. The osmotic pressures of the dissolved substances are calculated and substituted for the pressure in the gas formula $PV = RT$. Tables are given of the product PV. The conclusions are: The osmotic pressures of solutions of naphthalene, benzophenone, and diphenylamine in ether at 12°·90C at concentrations varying from 0·01 to 1·0 normal, indicate that none of these substances in solution behave like perfect gases, but like readily compressible gases, as the values of PV decrease with increasing concentration. This decrease is very marked in the case of benzophenone and less so with naphthalene; in the case of diphenylamine, the product diminishes up to 18 atmospheres, when it becomes constant or possibly increases. Azobenzene, on the other hand, investigated by Noyes and Abbot, very nearly approaches to the condition of a perfect gas. "It would seem very probable, that every substance when in solution has its own

characteristic condition equation connecting temperature, osmotic pressure and volume, analogous to every more or less compressible gas even when complications arising from ionisation or polymerisation phenomena are, from the nature of the solvent and solute used, highly improbable. Substances analogous to the permanent gases would seem to be the exception rather than the rule." S. S.

481. *Transference-Value of Hydrogen.* **W. D. Bancroft.** (Journ. Phys. Chem. 2. pp. 496–497, 1898.)—MacIntosh's conclusion that the Helmholtz method of determining transference numbers is not applicable to gas cells, is controverted, the variation in determinations of these numbers being pointed out. B. B. T.

482. *Variance of the Voltaic Cell.* **W. D. Bancroft.** (Journ. Phys. Chem. 2. pp. 427–440, 1898.)—A critique of Nernst's application of the phase-rule to the Clark cell, and a general consideration of the factors causing variability of E.M.F. of cells, and of the use of Le Chatelier's theorem to predict the sense in which the E.M.F. changes. B. B. T.

483. *Three-Component System.* **J. F. Snell.** (Journ. Phys. Chem. 2. pp. 457–491, 1898.)—The solubility of potassium chloride in aqueous acetone is determined at various temperatures, and the composition of mixtures which separate in two liquid layers. The behaviour of various other salts is determined qualitatively. B. B. T.

484. *Three-Component System.* **N. Dodge** and **L. C. Graton.** (Journ. Phys. Chem. 2. pp. 498–501, 1898.)—The temperatures at which two liquid layers are formed by aqueous ethyl alcohol in presence of excess of potassium nitrate are determined. B. B. T.

485. *Mixtures of Isomorphous Bodies.* **G. Bruni.** (Roma R. Accad. Lincei Atti, 7. 2. pp. 138–145, 1898.)—Both with regard to the temperatures of congelation and with regard to the distribution of the components between the liquid and solidified portions of the whole, mixtures of isomorphous substances completely follow van't Hoff's theory of solid solutions. A. D.

486. *Equilibrium of Two- or Three-Component Systems.* **G. Bruni.** (Roma R. Accad. Lincei Atti, 7. pp. 198–205, 1898.)—Where the components neither mix nor are isomorphous, there is complete parallelism between binary and ternary systems as regards their equilibrium; only in the latter there is always the third component in its solid phase. Where two of the components make a stable addition-compound, there is again complete parallelism with the same addition. Where two of the components make an unstable addition-compound, the result is analogous to the preceding at lower temperatures. Where two of the components are isomorphous, there is again complete parallelism with the same addition. Accordingly, if to a system of two components, with one possible liquid phase only, there be added a third component which does not combine with the former two, nor yet is isomorphous with them, the curves showing equilibriums of the same order (saturation curves in binary systems and curves of cryohydratic character in ternary systems) have a parallel course. Only, in the systems represented by the curve of the ternary mixture there always appears in addition, in solid phase, the third component added. A. D.

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487. *Equilibrium of Stereoisomers.* **F. K. Cameron.** (Journ. Phys. Chem. 2. pp. 409–416, 1898.)—Benzaldoxime is studied in the manner of Carveth's investigation of acetaldoxime (see 1898, Abstract No. 826). B. B. T.

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488. *Electrolytic Production of Crystallised Tungsten.* **L. A. Hallopeau.** (Comptes Rendus, 127. pp. 755–756, 1898.)—Lithium paratungstate, fused at about 1000° C., is electrolysed using platinum electrodes. After extraction of the mass with water, hydrochloric acid, and a solution of lithia, a residue of crystalline tungsten remains, which contains up to 6 per cent. of platinum derived from the electrodes. Iron electrodes are rapidly attacked by the fused salt. T. E.

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489. *Organic Electro-Chemistry.* **M. Krüger.** (Elektrochem. Ztschr. 5. pp. 98–105, 1898.)—This is a continuation of the author's previous historical papers (see 1898, Science Abstracts No. 1185) and relates to the action of electrolytic oxygen, chlorine, bromine, and iodine upon various organic compounds.

W. G. M.

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490. *Electro-Metallurgy.* **S. Cowper-Coles.** Eng. Mag. 15. pp. 594–602, 1898.)—This illustrated article deals with the following application of electrolytic methods in connection with the deposition or use of metals. I. Electro-galvanising. A

description of the author's frequently described process, with plans of an electrogalvanising plant. II. Electrolytic-pickling. (see 1898, Abstract No. 688.) III. The manufacture of parabolic reflectors. (See 1898, Abstract No. 545.) IV. The use of copper or tin as protective coatings for ironwork. An account of the methods used for coating the Dome of the Philadelphia City Hall, taken from the Electrical World for April 16, 1898. V. The use of brass as a protective coating for ironwork. Details of a method of depositing brass electrolytically from a cyanide solution of the two metals copper and zinc, using a sheet-brass anode. VI. Tin scrap recovery. A description of the two methods in which sodium hydrate and sulphuric acid are used as electrolyte respectively. (See 1898, Abstract No. 842.) VII. White lead manufacture. A description of six of the numerous patented electrolytic processes for the production of white lead. Only one of these is stated to be at work on an industrial scale. In this thin sheets of corrugated lead are packed between layers of coke or carbon, and strips of tin are used to make electrical contact between the lead and carbon. The remainder of the process is the customary Dutch process, but owing to the electrochemical action set up by the contact between the carbon and lead, the time necessary to convert the lead into carbonate is reduced by two-thirds. J. B. C. K.

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491. *Electrolysis of Alkali Chlorides.* **F. Winteler.** (Zeitschr. Elektrochem. 5. pp. 10–15, 49–51, and 217–221, 1898.)—A critical account is given of some of the chief facts and theories concerning the electrolytic production from alkali chlorides of (1) chlorine and caustic alkali, (2) hypochlorites, (3) chlorates and perchlorates. In the first and third sections, which form the greater part of the paper, the author treats of the choice of electrodes and diaphragms, and describes some experiments on the electrolysis of potassium chloride solutions, in which analyses were made of the anode and kathode fluids and also of the gases evolved. The bearing of the results obtained on the prevention of secondary reactions and on the conditions for economical working is discussed. N. L.

GENERAL ELECTRICAL ENGINEERING.

492. *Electrical Steering-gear.* **J. Fischer-Hinnen.** (Écl. Électr. 16, pp. 531–536, 1898.)—This article describes the arrangements devised by Giles (see La Lumière Électrique, xlix. p. 81, 1893), and Pfatischer (see 1898, Abstract 312), for this purpose. A number of diagrams are given and the theory of the two methods worked out. C. K. F.

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493. *Continuous Beams.* **H. J. Tomlinson** and **K. Pearson.** (Phil. Mag. 46. pp. 306–311, 1898.)—In a paper published in the Royal Society Proceedings, vol. lxii. p. 268, 1898, G. Wilson develops a novel method of finding the reactions at the points of support of continuous beams, which affords an easy solution for continuous beam problems, including those due to alterations in the levels of the supports. Wilson applies his method to a particular example by numerical calculation. In the present paper the authors show how the same problem can be treated graphically, a good draughtsman being able to complete the work indicated in 6 to 8 hours. The method is fully described and a sheet of reduced drawings is appended. A. S.

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494. *Direct-Reading Engine Power Gauge.* **G. F. Atwood.** (Elect. Engin. N.Y. 26. pp. 300–302, 1898, and Engng. News, p. 245, 1898.)—The function of this instrument is to continuously measure and give a direct indication of the mean effective pressure on the piston of an engine, without the necessity of taking indicator diagrams. The working principle of the instrument is the measurement of the steam pressure by the speed of a steam turbine, having sufficient inertia to make its speed constant for successive impulses of the motor. A tachometer is driven by the turbine motor, and this motor in turn is driven by steam from the cylinder of the engine through two pairs of nozzles connected to opposite ends of the cylinder. The indicating mechanism acts as a load on the motor; it consists of a fan attached direct to the turbine shaft, and adapted to drive a second fan mounted on a delicately pivoted shaft, having an indicated hand and being controlled by a spring. The angular deflection of the pointer is proportional to the speed of the turbine.

The paper in Engineering News gives many illustrations of the details of the instrument. A. S.

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495. *Engines for Electric Railway Power Stations.* **C. E. Emery.** (Street Rly. Journ. 14. pp. 244–261, 1898.)—This paper is a continuation of previous articles (see 1898, Abstract

No. 724), which describe the largest engines of the Corliss type. The present paper concludes the series and gives further examples of such engines, together with a number of high-speed engines which are provided with valve-gear adapted also for medium speeds. The special constructive features of each engine are fully described and illustrated. A. S.

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496. *Carbon Dioxide Motor.* (Frank. Instit. Journ. 146. p. 156, 1898.)—At a meeting of the Franklin Institute, W. F. Roberts described and exhibited in operation his carbon dioxide engine, which has three cylinders, each 2″ bore and 2″ stroke. The vertical engine measures $14 \times 10 \times 18$″. The claim is made that the engine is capable of running at 2,000 revs. per minute, under a pressure of 1,500 lbs. per sq. in., cutting off at $\frac{1}{64}$″. Under these conditions the engine develops 25 H.P. The total weight is 85 lbs. The engine is supplied with gas from steel cylinders containing liquid carbon dioxide which is heated in passing through a copper coil on its way to the engine. A. S.

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497. *Cleaning Water-Tube Boilers.* (Street Rly. Rev. 8. pp. 754–755, 1898.)—A description of a turbine water boiler cleaner made by the Chicago Boiler Cleaning Company. The tool comprises a turbine enclosed in a case $2\frac{5}{8}$″ diameter and 3″ long. To the turbine shaft the cleaner is connected by a universal joint which allows the tool to pass through curved tubes. The turbine revolves at about 2,000 revs. per minute. The arms of the cleaner are thrown out by centrifugal force, and the scale when cut away is washed out by the stream of water from the turbine. Eight tons of scale were so removed from five boilers in the power house of the Cleveland City Railway Company. A. S.

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498. *Coal-Handling Machinery.* (Street Rly. Rev. 8. pp. 721–723, 1898.)—The California Avenue station supplies current for the Chicago tramways. In the boiler-room there are ten water-tube boilers of 300 H.P. each. The coal storage house is a separate building 24 ft. wide by 200 ft. long. The coal is delivered in waggons, weighed on a platform scale, dumped into a hopper, reduced to fairly uniform size in a crushing machine, conveyed either into the coal storage house or into the bin in the boiler-room, and is fed from the bin to the stoker by chutes. A conveyer collects the ashes from below the boiler and deposits them in a bin outside the building. Descriptions are given of the coal-handling plant of the Toronto Railway Company, and of the power house of the Chicago City Railway at 49th Street and Oakley Avenue. At the latter power house the cost of handling

the fuel from the time it enters the yard to the time it goes out in the form of ashes is 16 cents per ton, and it is estimated that the saving effected pays 20 per cent. per annum on the capital invested in the machinery. A. S.

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499. *Calorific Power of Weathered Coals.* **R. S. Hale** and **H. J. Williams.** (Street Rly. Rev. 8. pp. 885–886, 1898.)—This paper was read before the American Society of Mechanical Engineers. Samples of Maryland, Virginia, Pennsylvania, and Ohio coals were collected. For tests of fine coal, the samples were ground and thoroughly mixed; for tests of lump coal, samples were broken into lumps of nut size. One set of samples was exposed on an uncovered balcony for eleven months; the method of exposure closely reproducing the conditions of the surface of a pile of coal left in the open. The samples were all analysed by H. J. Williams, and the results are given in tabular form. The conclusions to be drawn from the results are: (1) That weathering decreases by about 2 per cent. the theoretical calorific power, as calculated by Dulong's formula; (2) that weathering decreases by about one-half of 1 per cent. the actual calorific power, as shown by the bomb calorimeter; (3) that when it is desired to compare the respective calorific powers of weathered coals and of coals that have not been exposed, the use of Dulong's formulæ or of Kent's curve would lead to erroneous conclusions. A. S.

GENERATORS, MOTORS, AND TRANSFORMERS.

500. *Induction Generators.* **M. Leblanc.** (Comptes Rendus, 127. pp. 813–817, 1898.)—The author showed, in 1890, that if $2p$ denote the number of poles of an induction motor, ω its angular velocity, and n the frequency of the exciting current, then the machine acted as a motor so long as $\omega < \frac{n}{p}$, but that in order to make $\omega > \frac{n}{p}$, power had to be spent in driving the machine, energy being furnished to the polyphase circuit. In 1892 the author applied this property of induction machines to secure stability in the synchronous running of alternators, by surrounding the polar expansions with closed circuits consisting of heavy bars of copper. A machine so constructed may be regarded as a combination of an alternator with an induction motor, the armature of the alternator acting as a field-magnet towards the induced circuits on the pole-pieces. If the angular velocity ω should become $> \frac{n}{p}$, the induction machine immediately acts as a brake; on the other hand, if ω should momentarily become $< \frac{n}{p}$, the induction machine develops a driving-torque. The author states that this device has proved thoroughly satisfactory in practice. He next considers the practicability of employing an induction machine as a generator. This would do away with the necessity of synchronising it before connection to the supply mains. A description is given of an induction generator, with a special form of exciter. The winding is so arranged that although a large air gap is used the effects of magnetic leakage are neutralised. A. H.

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501. *Running Shunt Dynamos in Parallel.* **A. Philip.** (Electrician, 42. pp. 161–162, 1898.)—The considerations and the experiments dealt with by the author in this article are based on the recent breakdown at Brighton. Special precautions have to be taken when shunt machines of different design are run in parallel. The speeds and resistance in the shunts are adjusted, so that, as nearly as possible, the electromotive forces of all the machines may rise and fall in the same ratio when the load on the bars varies. If the load increases the consequent drop in the electromotive force developed in the armature must be the same. This means that either the machines shall be of identical design, or that if of different types the resistances in their shunts and their speeds shall be so adjusted that they shall all work at about the same magnetic induction in their field-magnets. If the

adjustment has not been made very well a very large increase of load may cause the distribution of load to vary so greatly that a motoring of one or more of the machines might occur—that is, the load might be entirely removed from them and converted into a negative one. The greater the alteration of the 'bus-bar pressure, the greater is the danger that this accident may occur. If the machines whose loads are thus lightened are furnished with minimum current cut-outs they will not motor, but will be removed from the bars. A sudden drop in voltage on the 'bus bars may occur (1) by decreasing the resistance between the 'bus bars, as, for instance, by a short circuit of the bars; (2) possibly by the breaking of a shunt circuit, even when the armature had been removed from the bars; (3) by a short circuit in the armature windings of one of the machines; (4) by suddenly switching out one of the dynamos when giving some considerable fraction of the total current. The behaviour of the dynamos under these different conditions is fully discussed.

In the case of a dead short circuit of the 'bus bars, if the armatures do not burn out, they will run round the lower limb of the dynamo characteristic curve and cease to give any current at all, or if provided with minimum current cut-outs these will take them off the bars. If, however, one or more of the machines are working with their field-magnets excited to a flatter position of the BH curve than the others, then these will take most of the load, and the remaining machines will be cut out by their minimum current cut-outs; whilst, finally, the machines thus left on the bars will cut out with their excess current fuses, or failing this they will run round the lower limb of the characteristic curve and give zero current.

The fact that at Brighton the main fuses on two of the machines are said to have remained intact whilst the machines were still on the bars appears to render the supposition that the breakdown was due to a dead short across the bars somewhat improbable. The author suggests that the breaking of a circuit from 'bus bar to 'bus bar which has large self-induction, and carrying a large current (such as the shunt coil of a machine), might cause a marked fall of pressure. He is, however, unable to definitely state that this would occur, as he has not had the opportunity of making the test on a sufficiently large scale.

With regard to the third contingency it is supposed that the armature is short-circuited by some accident from brush to brush, outside the brushes but inside the minimum cut-out. The current in the armature would then suddenly increase enormously, and as the brushes here lead there would be a sudden weakening of the magnetic strength of the shunt field, and consequently a sudden rise of E.M.F across it in the same direction as would be the case if it were broken. In fact, the armature would act like the primary of a step-up transformer, of which the shunt windings form the secondary. The E.M.F thus set up in the shunt would act so as to lower the potential across the main, or even possibly

reverse it. It should also increase the armature currents of the machines still remaining in parallel, and weaken their shunt circuits. In order to test the magnitude of this effect the author performed an experiment, which he describes fully in the article.

Lastly, the sudden removing of the armature from circuit by means of the minimum cut-out would of itself cause a drop in the bars, and the two effects added together may account for the large similar type dynamos (if they were working on a less saturated field than the two smaller ones) cutting out and finally leaving the other two alone on the bars.

It may be added that even if all the dynamos in parallel have precisely similar armature reactions, and are all working on the same portion of the magnetisation curve, yet a *sudden* fall of pressure on the bars may cause those machines whose shunt windings have the smaller time constants to drop their electromotive forces more rapidly than those machines whose shunts have larger time constants; and if this was the case at Brighton, one would expect that the shunt coils of two smaller machines had larger time constants than the larger machines whose minimum current cut-outs acted. L. J. S.

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502. *Multiphase Armature Windings.* **J. P. Stone.** (Amer. Electn. 10. pp. 456–458, 1898.)—The author describes, with diagrams, bar windings for multiphase armatures. Wave winding has many advantages over lap winding. When there are two bars in each slot, all the top bars at one end have their ends bent in one direction, and all the bottom bars in the opposite direction, and as each bar spans half the distance between the slots, the two ends which come directly over each other are joined by a clip. Any continuous current winding can be used for alternating work, but the reverse is not true. R. B. R.

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503. *Armature Windings.* **A. L. Rice.** (Amer. Electn. 10. pp. 501–502, 1898.)—The author describes a four pole parallel wound drum-armature with three distinct circuits on it, that is to say, each conductor carries one-twelfth of the whole current. This he calls a four pole, four circuit armature, with triple telescope winding. He also describes a two pole gramme armature with two circuits, and apparently calls this a telescope winding also. R. B. R.

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504. *Walker Railway Motor.* (Amer. Electn. 10. p. 181, 1898.)—The author illustrates and describes an 80 H.P. Walker motor to be used on the Brooklyn Elevated Railway. The frame of the motors is made entirely of cast steel, the magnetic ring being circular in form and containing four laminated field-magnets with pole shoes. Each one of the magnets is wound

with bar copper, insulated with asbestos, forming a perfect fireproof coil.

The armature is hollow and provided with air ducts running radially through the laminations to ensure perfect ventilation. The winding is made from bar copper, with only one turn for each commutator bar. The modern practice of very few slots is used for the armature, with four inductors in each slot, the insulation being entirely of mica, rendering it also fireproof. The frame of the motor is left practically open for complete ventilation, so that the heated air on the interior of the motor can escape freely, thereby increasing the capacity for the motor for sudden and heavy over-loads. The motor is so designed that it will not spark under any condition of load, and can take currents two or three times the normal current of the motor with good efficiency and without damage to any part of the machine. The current density in the commutator brushes is about 35 amperes per square inch. L. J. S.

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505. *Combined Transformer and Rectifier for Polyphase Currents.* **J. Sahulka.** (Zeitschr. Elektrotechn. Wien, 16. pp. 405–409, 429–431, 1898.) — This paper describes two methods of rectifying polyphase currents without the use of a motor-generator. The first of these is due to Hutin and Leblanc (German Patent, No. 78825) and consists in that the secondary windings of the stationary transformer serving for the transformation of the high-tension polyphase currents, are each formed of two systems of oppositely wound coils which are connected together and with the segments of a collector on which slide two brushes moved by a small synchronous alternate-current motor, the current for which can be taken from one of the systems of coils. A continuous current of more or less uniform strength can be taken from these brushes.

The secondary coils, in the examples given, are of even number—*e.g.*, eight—and for a monophase-current primary are arranged side by side along the core, so that the first half of them—*e.g.*, the first four—are wound in an opposite direction to the last half—*e.g.*, the last four—and the whole of these secondary coils are connected up in series in a closed circuit, so that, if a current were passed through this circuit, the brushes being out of contact with the collector, their resultant magnetising effect would be zero. The connections between the adjacent coils are connected to the segments of the commutator, so that, as the brushes (which are arranged diametrically opposite each other) slide on the commutator, the secondary coils supply a rectified current to the continuous-current-circuit, which pulsates between zero (when equal numbers of oppositely wound coils are in series with each other) and a maximum value (when the two sets of oppositely wound coils are in parallel with each other).

To reduce the speed of the brush-holder, the motor can be made multipolar, at the same time increasing the number of collector-segments, *e.g.*, if the motor have eight poles, the number of segments must be four times that of the number of coils in the secondary circuit; each four segments 90° apart are connected, and the brushes are 45° apart. The pulsations of the rectified current can be reduced by inserting a coil having self-induction into the circuit.

In order to obviate the use of a coil having self-induction, two-phase or multiphase alternating currents must be employed. These can be converted into low tension currents by single transformers, or by a combined multiphase-current transformer. All the secondary circuits must consist of two systems of coils arranged as above mentioned. For two alternate-currents having a difference of phase of 90°, the currents magnetise separate cores which each have, say 12, secondary coils in two oppositely wound groups. The E.M.F. induced in one group of coils on core I may be indicated by E. sin α, that induced in one group of coils on core II by E. cos α; the phase of the latter being a quarter-period in advance. Since in the present case the rotation of the brushes on the collector during a quarter-period corresponds to the space of three coils, the coils of the two secondary circuits should be connected together so that each coil of core I is in series with a coil of core II, the number of which is three higher, the coils of core I being connected to the commutator as described in connection with the monophase arrangement. In this arrangement, the E.M.F. in the continuous current circuit varies $\pm 14{\cdot}7$ per cent. By making some of the coils on each of the cores, say, Nos. 6, 7, 1, 12, with only $\frac{1}{3}$ the number of turns as the others, the pulsation may be reduced to $\pm 2{\cdot}22$ per cent.

With triphase currents three cores are employed, each with, say, 12 coils as before. Since a difference of phase of 120° corresponds here to a space of four coils, coil 1 of core I is to be connected in series with coil 5 of core II and this with coil 9 of core III which is connected to coil 2 of core I, and so on. The coils of core I are connected to the commutator as before. This arrangement, with like coils, gives a pulsation $\pm 7{\cdot}18$ per cent.; with coils 6 and 12 on each core omitted, but the connections to commutator otherwise the same, the pulsation is $\pm 0{\cdot}52$ per cent. Diagrams of various arrangements are given together with a plan of an actual apparatus for triphase currents. This process can also be used for converting continuous currents into polyphase currents.

In the other class of apparatus the action is as follows, taking as an example the apparatus designed by Zipernowsky and Déri (Ger. Pat., No. 51596), where separate coils are employed for the several polyphase currents and for the continuous current, viz.: A rotary magnetic field is produced by the polyphase currents in a stationary Gramme-ring- or drum-armature; the ring or drum

winding is connected with the segments of a stationary collector on which slide brushes which are rotated by means of a synchronously running armature, and from these brushes a continuous current can be taken.

Several of these transformers are illustrated; the author objects to this latter form of apparatus, on the ground that it must necessarily be as expensive to construct as the ordinary motor-generator converters and makes the following suggestions:—

1. The device for taking off the rectified current should not be arranged on the transformer itself, but separately, as is the case in the Hutin and Leblanc transformer; the transformer thus need only have bi-polar winding, whilst the small motor which turns the current-collecting device alone need have multipolar winding.

2. Since the transformer itself can comprise no rotating part, the ring or drum form of armature can be relinquished, and very simple forms of frame can be employed, so that the apparatus may be of the ordinary alternate-current transformer form; by this arrangement also the resistance of the magnetic circuit can be very much reduced.

Several forms of apparatus embodying these suggestions are described and illustrated. C. K. F.

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506. *Rotary Converters.* **E. de Marchena.** (Ind. Élect. 7. pp. 329–331, 354–356, and 378–382, 1898.)—This is a lengthy mathematical discussion of rotary converters which is difficult to abstract. The following are some of the conclusions arrived at:—

1. There is no advantage in compounding alternators for feeding rotary converters. Alternators with considerable self-induction are suitable for the purpose and will give a minimum wattless current on a line with variable load.

2. When an alternator is compounded to give a constant potential difference between its terminals for all loads, or, when a converter is connected between constant potential mains, the resistance and self-induction of the transformers and the line will not in general be sufficient, and to avoid excessive currents an inductance must be placed in series with the converter.

3. There is no advantage in determining the excitation of the converter for unit power factor for full load. It is preferable to annul the wattless currents for a less value of the load, say for 70 or 80 per cent. of full load.

These results have been obtained on the assumption that power absorbed by the converter when running light may be neglected. W. G. R.

POWER DISTRIBUTION, TRACTION, AND LIGHTING.

507. *Tests of Traction Plant.* **G. W. Munro.** (Street Rly. Rev. 8. pp. 728–730, 1898.)—Purdue University students tested the 750 H.P. plant at La Fayette, and give curves of current used during the working of the road and the output and efficiency at different times of the day. Owing to unfavourable load-factor, the boilers, which were tested with coal and with natural gas, showed a very low rate of evaporation. A ton of coal was equivalent to only 13,560 cubic feet of gas at atmospheric pressure and 62° F., instead of the usual 30,000 cubic feet. The exhaust steam heater furnished 13·6 per cent. of the heat given to the water without perceptibly increasing the back pressure. The running expenses using gas, were 1·11 cent per kw. hour output, and 1·65 cent per car mile: using coal, these figures were respectively 1·73 cent and 2·5 cents. E. H. C.-H.

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508. *Test of Power Station.* (Street Rly. Rev. 8. pp. 875–878, 1898.)—Elaborate tests extending over forty-five hours with twenty-four observers were made at the Harvard Station of the Boston Elevated Railway Company. There are six Babcock boilers having a total capacity of 3,000 H.P. The chimney-stack 16 feet diameter, is 226 feet high, and the flue contains a 560-tube Green economiser. The three main E. P. Allis engines have cylinders 28 and 56 by 60 in., and are cross-compound, jet-condensing, rated at 1,800 H.P. each, and 150 lbs. pressure. Their 24-feet fly-wheels each weigh 60 tons. They are direct-coupled to 12-pole 1,200 kw. generators at 80 R.P.M. Some of the chief results are:—

Equivalent evaporation from and at 212° F. per lb. dry coal (boilers and economiser)	10·68 lbs.
Percentage of total heat contributed by economiser	7·62
Steam per hr. per I.H.P. of main engines	14·05 to 15·13 lbs.
Coal ,, ,, ,,	1·47 to 1·56 lbs.
Condensing water per hr. per I.H.P. of main engines	344 to 432 lbs.
Efficiency (E.H.P. to I.H.P.)	88·8 to 90·9 %
E.H.P. to run feed pumps	13·4 to 15·3

E. H. C.-H.

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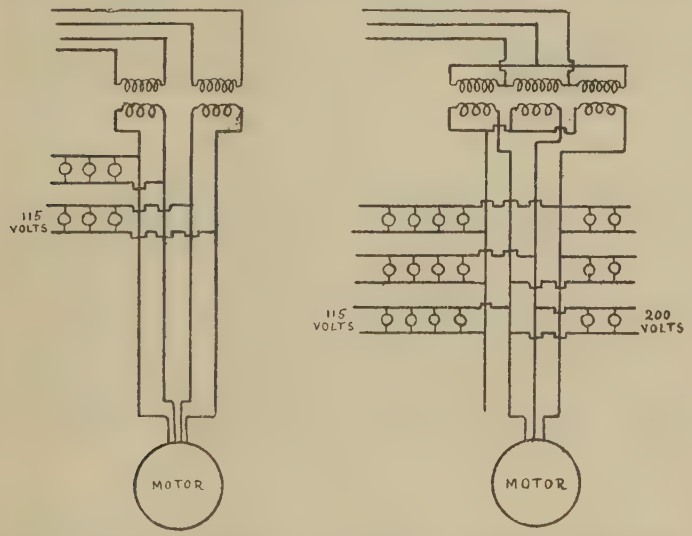
509. *Multiphase Systems for Central Station Service.* **W. S. Kelley.** (Elect. Engin. N. Y. 26. pp. 281–284, 1898.)—It is well known that a multiphase system is preferable to a single alternating circuit only when a satisfactory combined lighting and *power* service is required at all points of the distributing network. The only multiphase systems which have to be practically considered are the two-phase and three-phase systems. For two reasons the interlinked or three-wire two-phase system has not proved a

success: (1) on account of the higher P.D. which exists between the outer mains; (2) because of the unbalancing which takes place, even with an equally distributed load, on account of inductance. Comparing the two-phase with the three-phase system for a combined lighting and power service, the author arrives at the following results:—

		Number of Wires.	Weight.
Primary Network...	2-phase	4	4
	3-phase	3	3
Secondary Network	2-phase	4	100
	3-phase	4	$29\frac{1}{4}$

The two systems are illustrated in the accompanying diagrams. It will be seen that in the case of the three-phase four-wire secondary network, a slight change in the connections of the secondaries,



either at the transformers or at a centre of distribution reached by the four secondary wires, the voltage across the wires can be quickly changed from 115 to 200. With regard to the question of balance, advantages have been claimed for the two-phase system, but recent practice has shown that in this respect also the three-phase system is superior. The author concludes that the three-phase system has decided advantages, in every respect, over the two-phase one. A. H.

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510. *Economy in Small Electric Light Stations.* **E. P. Roberts.** (Elect. Engin. N.Y. 216. pp. 292–293, 1898.)—These articles contain a careful examination of all points connected with power stations in which economies may usually be effected, and indicate the best methods of estimating the pecuniary results of the alterations suggested. M. G. W.

511. *U.S. Electric Lighting Company's Station at Washington.* **N. M. Hopkins.** (Elect. Engin. N.Y. 26. pp. 425–433, 1898.)—Contains a detailed account of the new power station with photos of the plant, &c. The new power installed is about 4,800 H.P. M. G. W.

512. *Electricity in Printing.* **G. A. Damon.** (Elect. World, 32. pp. 499–504, 1898.) The more notable parts of the power plant are a steel chimney unstayed 125 ft. high by 54 in. diameter; Corliss valves with engine speed 125 r.p.m.; armatures with hollow shafts direct driven and so aligned that either engine can drive any or all of the dynamos by a shaft through the hollow armature. The 40 presses are direct-coupled to motors at 120 r.p.m. Speed regulation from full speed to 75 per cent. is effected by field regulation, cutting in series windings in sections: from 75 per cent. to 5 per cent. resistances are introduced in the armature circuit. Regulator connections are sketched. M. O.'G.

513. *Electrical Plant for Docks and Harbours.* **J. D. W. Aldridge.** (Elect. Engin. 22. pp. 565–568, 1898.)—In this paper, read before the British Association, at Bristol, the author gives load diagrams showing the variations of the demand for light and power during one week in dockyards, and states that the combination of the plant for both purposes leads to economy. The machinery in use at various ports is briefly described, and a table is given showing the hours of working, receipts, expenses, &c., for each of twelve months in the case of sixteen electric cranes at Rotterdam. The energy required by an electric crane is estimated at from $3\frac{1}{2}$ to 5 units per hour. A. H. A.

514. *Submerged Conduits for Crossing Rivers.* (Elect. World, 32. pp. 442–443, 1898.)—Cables drawn into waterproof conduits are preferable to armoured cables for crossing rivers; two such conduits are in use at Boston, U.S.A. One of these consists of seven wrought-iron pipes, each 4 inches in diameter, enclosed in a wooden shell 4 inches thick and 24 inches in external diameter; the wooden pipe is built up in sections from $1\frac{1}{2}$ to 6 feet long. The whole is of the form of the letter U, and is lowered into a trench in the bed of the river. The other conduit consists entirely of wood, having twenty-four ducts, and is built up of seven layers, each 6 inches thick, in sections 4 feet to 20 feet long; the complete conduit weighs 40 tons. Lead-covered cables are drawn into the ducts in both instances. A. H. A.

515. *Belfast Electric Supply Works.* (Electrician, 41. pp. 837–845, 1898.)—This is an account of the Belfast Electric Supply Works, and is interesting on account of the use of gas for motive power. Although the use of gas power is said to work satisfactorily, a supplementary station is being erected in which steam engines will be used. The equipment of the engine-house consists of three sets of continuous-current steam dynamos, the steam engines being built by G. E. Belliss & Co., and the dynamos by Thomas Parker. A fourth set is in course of erection. Two of the Belliss-Parker sets consist each of a Belliss engine placed between two 50-kilowatt balancing dynamos direct-coupled on one shaft. The larger set consists of a single three-crank engine, coupled direct to a 200-kilowatt continuous-current dynamo, capable of delivering from 440 to 500 volts. The table given below shows tests of these engines and dynamos. A novel feature of the switching arrangements is the introduction of mechanical gear in place of electrically connecting the wires for the regulating resistances. Immediately in front of the switch-board are a number of regulator wheels, supported on iron pillars. These do not directly actuate the electrical contacts controlling the regulating resistances, but operate a system of connecting rods and bevel gearing, by which contact-pieces, at some distance from the board and in a place of greater security than on the board, are efficiently controlled.

TRIALS OF BELLISS-PARKER STEAM DYNAMOS.

TEST I.—100-Kilowatt Set.—Steam Consumption in Pounds per Electrical Horse-power Hour.

Load.	Condensing (pounds steam).	Non-Condensing.
20 % over	20·27	23·0
Full	20·6	24·32
¾	21·02	26·9
½	21·37	31·53
¼	22·74	40·99

TEST II.—200-Kilowatt Set.

20 % over	22·0	24·9
Full	22·0	26·1
¾	23·3	28·5
½	25·1	33·3
¼	26·2	44·1

W. G R.

516. *Snoqualmie Falls Transmission Plant.* (West. Electn. 23. pp. 99–100, 1898.)—This is an account of the three-phase plant which is being installed at Snoqualmie Falls to provide power for the cities of Scattle and Tacoma. The total water power available throughout the year is 30,000 H.P. The alternating current will be generated at 1,000 volts and transformed up for transmission at 25,000 or 28,000 volts. The line wire will be of aluminium, No. 2 and No. 3 B and S gauge. The estimated cost of the plant is $500,000. W. G. R.

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517. *Liverpool Electric Tramways.* (Electrician, 42. pp. 99–104, 1898.)—This is the first example of municipal electric light and traction systems being combined under one roof. At present 6¼ miles of track have been experimentally equipped on the trolley system, partly with centre poles and partly with span wires. Two trolley wires of 0·4 in. diameter run centrally over the tracks throughout. Two 0·4 sq. in. feeders are used, laid on Callender's solid system in iron troughs. The Board of Trade pilot cables are contained in 3-core 7/18 conductors, lead-covered and armoured, two of the cores being used as a series telephone circuit 17,200 yds. long, the conductor forming a continuous loop, into which the instruments can be inserted at the feeder pillars and a few other points. Car sheds for 50 cars with small repair shops are nearly completed. The German and American types of car are being tried. The former are of the pattern used at Hamburg on rigid trucks with two 20-H.P. Schukert motors. They hold 20 passengers; similar trailers hold 18. The American cars have Brill maximum traction trucks and Walker equipments. One car is fitted with a standard air-brake actuating the same blocks as the hand-brakes. The air-pump is worked off the axle. All the cars have electric emergency brakes. The generating plant comprises three non-condensing Willans-Siemens 300-H.P. generators, to which will be added similar 1,500-H.P. sets. There is no fly-wheel to the latter sets, the necessary weight being located in the armature. There are also 246 E.P.S. cells with 21 plates, giving a maximum of 480 amperes at 550 volts for one hour. The tramway switch-board consists of three panels. The main panel contains d.p. switches and s.p. fuses for the generators and the cells; also a circuit breaker and two meters, one working in either direction on the battery circuit, which also passes through a recording ammeter. The capacity of all the switches is 300 amperes, but the circuit breaker is set normally at 500 amperes and potentially at 800. The booster panel contains two s.p. throw-over switches for connecting the line-feeder and track-feeder to the 'bus bars direct or through the booster. The Board of Trade panel contains two low-reading recording voltmeters, one recording ammeter reading to 10 amperes, and an ammeter with two scales

of 0·0005 to 0·005 and 0·05 to 5 amperes. The booster will consist of three E.C.C. machines rigidly coupled in line. The centre machine is a 500-volt shunt motor, the outside machines being series-wound generators giving a potential at any speed proportionate to the current, up to a maximum of 300 amperes, and having their magnet coils in series with one of their armatures.

The total cost of the construction and equipment of the $6\frac{1}{4}$ miles of tramway in this experimental line is estimated at £82,000, viz., £33,000 for the line construction and equipment, £24,000 for the total of 45 cars, and £25,000 for the car sheds and workshops. E. H. C.-H.

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518. *Chicago Elevated Electric Railroad.* (Electrician, 42. pp. 110–114, 1898.)—Illustrations show the power station and third rail construction at a cross-over track. The power house, which is compactly placed under, and between, the up and down lines of the 4-track way, contains two 2,500-H.P. and two 1,200-H.P. units. Condensing water for the vertical compound engines is brought from and returned to the river, a mile away. Of the General Electric generators, the smaller have 10 poles and carry 18 ft. fly-wheels weighing 45 tons, and running at 75 r.p.m., while the larger machines have 12 poles and 25 ft. fly-wheels weighing 70 tons each and running at 100 r.p.m. The twelve Babcock boilers have Babcock stokers chain driven by two oscillating engines. The chimney shaft is 150 ft. high by 12 ft. 6 in. internal diameter and is supplemented by two large centrifugal fans. The 90-lb. track rails are each bonded at their centres to the steel structure. The third rail consists of 45-lb. channel iron elevated slightly above the timber safety guards and carried either on one or the other side of the track according to the position of the points, &c. At intervals of 5 ft. the third rail is carried on square blocks of pine saturated with paraffin wax and resting on iron pedestals.

The 40-passenger motor cars haul one or two trailers, have cabs at each end, and are carried on independent bogeys, each equipped with a 100-H.P. motor of the G.E. 2,000 type. The cab at one end contains a 3-H.P. motor for working the air-pump for the brakes. On both sides of the car there is a front and back shoe carried on stiff springs. Each motor truck is inspected every three days. E. H. C.-H.

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519. *Electric Tramways in South Africa.* (Street Rly. Journ. 14. pp. 211–215, 1898.)—The Cape Town and Port Elizabeth tramway systems are described, these having been equipped on American methods. The Cape Town line has a length of 22 miles of single track, with a maximum grade of 7 per cent., and a minimum curve radius of 38 ft. The Port Elizabeth line is $10\frac{1}{2}$

miles long, divided into 4½ miles of double track and 2 miles of single track. The maximum grade is 1 in 8·55.

The trolley wire is No. O B and S gauge. Part of the feeders are underground and part overhead. The average drop allowed on the feeders is 5 per cent., with a maximum of 10 per cent. The drop on the return circuit is limited to 7 volts.

L. J. S.

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520. *Union Traction Company of Philadelphia.* (Street Rly. Journ. 14. pp. 691–700, 1898.)—The above company operates, through consolidations and by leases, about 450 miles of track in the city of Philadelphia and its suburbs, and earns nearly $11,000,000 gross. It is the largest street railway property in the world.

The arrangement of staff and the expenses and profits of the system are stated in this article. The company now operates its lines from seven main power stations, and three sub-stations, while three stations have been abandoned. The location of these stations is shown on a map, and the character of their equipment is shown in a table.

The dynamos for the main station were manufactured by the Westinghouse Electric and Manufacturing Co.; there are four machines of 1,500 kw. each. The field has 14 poles built up of laminated steel and cast in the yoke. At the pole tips the corners of half the laminations are cut away, leaving but half the pole section at the edges, but with full section at the centre. The proportions of the corners are such that the field distortion with load is comparatively small, and the strengthening of the magnetic field due to the series coils is principally at the commutating pole-tip. The series and shunt coils are separately wound and insulated, and have an air space between them when in position on the field. This prevents the conduction of heat from one to the other. The armature is 128 in. in diameter, of the slotted type, with bar windings, and is parallel wound. The coils are made of copper strip bent into the exact shape, and insulated before placing on the coils. The construction of the armature core is such as to dispense with bolts for clamping the core or end plates. A characteristic feature of the armatures of these machines is the balanced condition of the magnetic circuits. By special construction, the magnetic strengths of the different field poles are kept equal, independent of inequalities in the magnetic circuits. By this means the parallel wound armature is able to give equal E.M.F.'s on all its fourteen circuits under any conditions. A field coil may be short circuited or even reversed, and the machine will continue to operate well. The armature may be out of centre without producing any appreciable effect on the commutation or undue magnetic drag. The weights of the different parts of the dynamo are given. The arrangement of switchboard is fully described. Great care is taken

to keep the lead sheathing of the cable always negative, so as to prevent electrolysis, and an inspector is constantly making tests all over the system to accomplish this result. L. J. S.

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521. *Chicago Elevated Railway.* **J. R. Cravath.** (Elect. Engin. N.Y. 26. pp. 368–369, 1898.)—Curves are given showing the effect produced by introducing a storage battery to meet the fluctuations on this line. W. R. C.

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522. *Johnson-Lundell Surface Contact System.* **E. H. Johnson.** (Elect. Engin. N.Y. 26. pp. 516–518, 1898.)—The author remarks that American Street Railway Companies do not desire the success of any system of traction other than the trolley, as, by their leases, they can be compelled to adopt any practicable system. He then refers to the past history of surface contact systems, and finally states that the cheapness of the Johnson-Lundell electro-magnetic system justifies its adoption wherever the overhead trolley is now a financial success. The switches, of which details are given, are made up complete in the factory in cases ready to be placed in the outer boxes supported between the track sleepers. E. H. C.-H.

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523. *Murphy Third Rail System.* (Street Rly. Journ. 14. p. 231, 1898.)—The article describes and illustrates a new system of sectional third rail, due to S. M. Murphy. The method consists essentially in exciting the section of third rail over which the car is about to pass by electromagnetic means, and cutting the section out of circuit automatically after the car has passed. Every car carries upon it, under the seats, a 10-cell storage battery, giving about 20 volts. The batteries are employed only when the car is starting, and then only to make the necessary connection between the feeder supply and the third rail section over which the car is standing. To do this they drive a rotary converter which produces 500 volts at its generator end, exciting an electromagnetic switch which automatically connects the section on which the car is standing, and the one immediately in front of it, with the main source of supply. The 500-volt current is then admitted to the motor, and the car proceeds as in ordinary practice. After starting, the rotary converter operates in the opposite way, charging the battery until it is again needed. The electromagnetic switch cuts out the sections after the car passes, rendering them dead. The chief feature of the system lies in the construction of the switch, which is the critical point of a system of this kind. The important point of the switch lies in the method of preventing arcs, which is effected by employing a secondary and independent fine wire winding which is short

circuited on itself by means of carbon contacts, when the thick wire or active coil is opened, and which is itself finally opened after the latter operation. Both circuits are opened by means of carbon brakes.

Full details are given of the form of shoe contact employed. The article describes further a method of carrying the motor on the car which is also applicable to the trolley system and to all types of motors. Roller bearings are introduced at the axle bearing of the motor, greatly reducing the friction at this point. The system is equally applicable to surface or elevated roads, and can be installed while the cars are in operation by any other power without interfering with traffic. L. J. S.

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524. *Comparative Costs of Cable, Electric, and Horse Traction in New York.* (Street Rly. Journ. 14 pp. 721–724, 1898.)—This article, for the first time in the history of street railroading, gives a true comparison of the relative cost of operation of cable, electric, and horse railways in a single city and under substantially the same conditions by a company controlling the local transportation of over 250,000,000 passengers per annum. On broad principles the company's experience points unmistakably to the great superiority of electricity over both horses and cable, not only in traffic handling capacity, but in economy.

On January 1, 1893, the entire street railway system of New York City was operated by horses. The importance of doing away with horse traction, in the interests of both the city and the company, became so great, however, that it was at last determined to try the underground conduit electric system, which had previously been a failure in America wherever installed, owing partly to climatic conditions and partly to an attempt to use too shallow and cheap a conduit. From the first experiments onwards the conduit system proved a thorough success.

The annual and quarterly reports included in this article show that during the twelve months' period the company operated 34·2 per cent. of its car mileage by the cable system, 20·2 per cent. by the electric system, and 45·6 per cent. by horses. During the last quarter, however, the proportions were greatly changed, the cable mileage being only 27·2 per cent. of the total, the horse 33·7 per cent., while the electric had risen to 39·1 per cent.

The relative traffic densities, measured by the receipts per mile of track and per car mile as shown in the quarter's report, are as follows: cable, $39,000 per mile of track and $·333 per car mile; electric, $17,000 per mile of track and $·260 per car mile; and horse, $8,000 per mile of track and $·288 per car mile. The average earning power of the entire system was about $14,000 per mile of track and $·29 per car mile. These figures per track mile are for the quarter only. Another gauge of traffic density is found in the statement that the 11 per cent. of the company's

entire mileage which is operated by the cable system is earning 28 per cent. of the total passenger receipts; the 28 per cent. which is operated by the electric system is earning 32 per cent. of the total passenger receipts; and the 61 per cent. which is operated by horses is earning but 30 per cent. of the total passenger receipts.

For the year, the operating expenses of the cable lines were 16·42 cents per car mile, of the horse lines 17·87 cents, and of the electric lines 10·23 cents. For a three months' period offering more favourable circumstances for electric traction the cable lines cost 17·55 cents, the horse, 17·89 cents, and the electric 10·06 cents. The electric lines during the twelve months' period earned 16·76 cents net per car mile, or but 1·25 cents less than the cable system, in spite of the fact that the latter has 7·43 cents per car mile greater receipts, while for the three months' period the net earnings of the electric lines per car mile were actually greater than the cable lines by ·25 cents, and greater than those of the horse lines by 5·04 cents.

It overturns all established ideas to find that two temporary electric power stations can actually produce power for heavy electric cars 22 to 28 feet in length at a cost less by 30 per cent. (in the quarterly statement) than can be done in two cable power stations which operate cables so heavily loaded as to make the proportion of live to dead weight greater probably than that of any cable railway system in America, except with the possible exception of the State Street line of the Chicago City Railway Company. In the transportation expenses we find again that electric traction is the cheapest of the three motive powers, and the reason for this is found chiefly in the greater speeds of car possible with electric traction, which increases the service divisor. In the quarterly statement it is seen that in every grand division of operating expenses electricity has a decided advantage over the cable system, and in every division except maintenance of equipment it has an advantage over the horse system.

During the twelve months' period the cable lines operated at 47·7 per cent. of their passenger receipts, the electric lines at 37·9 per cent., the horse lines at 65·3 per cent., and the entire system at 53·3 per cent. During the three months' period the cable lines operated at 52·7 per cent. of their passenger receipts, the electric lines at 38·6 per cent., the horse lines at 62·1 per cent., and the entire system at 50·9 per cent. It should not be hastily assumed from the above statements that the conduit system could be adopted with financial or engineering success by street railway companies in general. New York City and Washington, which have the only electric conduit roads of any size found in America, are peculiarly favoured in the matter of climate and cleanliness of streets, the rainfall and snowfall during the year being extremely small. L. J. S.

525. *Comparative Traction Costs.* **W. A. Harding.** (Street Rly. Rev. 8. pp. 906–907, 1898.)—In a paper on Practical Points in Street Railway Engineering the author quotes the following figures from a report of the President of the Metropolitan Street Railway of New York :—

Expenses of operating horse cars 17·87 cents, cable cars 16·42 cents, and electric cars 10·23 cents per mile. E. H. C.-H.

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526. *Rail-Bonding in Brooklyn.* **R. P. Brown** and **G. E. Chapin.** (Elect. World, 32. pp. 311-312, 1898.)—Report of the Committee on Bonding, presented to the N.Y. State Street Rly. Assoc., September, 1898. In 1895 it was decided to replace the old rails, which carried practically no current, by well bonded 9 in. girder rails. After removing scale from under the base of the rail by a portable emery wheel, a cast copper plate was clamped by iron plates to the ends of the rails, covering 12 sq. in. on each rail and in contact up to within $\frac{3}{4}$ in. of the end of the rail, whence the metal was curved to allow for expansion. Attempts made to seal these bonds watertight with non-hardening pitch were unsuccessful; nevertheless, recent tests show that rust has not yet affected their resistance. This method was not more costly than the use of $\frac{1}{0}$ bonds, but required close supervision, to obviate which an electrically brazed bond was adopted in 1896, and is now the standard. It is now placed on the base and upper flange of the rail outside the fishplate, and consists of a dozen leaves of soft copper $\frac{1}{64}$ in. thick, the carrying portion being $\frac{3}{4}$ in. wide, and the brazed contact being 1 sq. in. in area. Soft spelter and a flux are used in brazing. For flexibility the bond is divided longitudinally into three parts; its length between centres of contacts is 5 in., and its equivalent section is 350,000 mils.; all rails are double bonded. Owing to absence of a portable brazing apparatus, the bonds were made in two parts and brazed on in the yard, the ends being interlaced, riveted, and soldered when the rails were in place. Consequently some of the branch lines could not wait for brazed bonds, and were bonded with horseshoe bonds, $3\frac{1}{4}$ in. long, placed under the fishplates. Any irregularities in the holes, due to drilling at maker's and subsequent reaming out with emery paper, are filled up if care is used in compressing the terminals, whose diameter is $\frac{3}{4}$ in. Special work is better bonded outside the fishplates. Straight track is cross-bonded every 750 ft. by copper wire connected to a brazed terminal having 6 sq. in. of contact. These terminals are bolted to the rails to prevent mechanical strain on the joints. The Falk cast welded joints make the best possible electrical connection. Joints are tested by taking simultaneous readings with two Weston millivoltmeters, one across the joint, and the other across 2 ft. of solid rail.

The following results have been obtained :—

	Drop per foot.		Relative Conductivity (Solid Steel = 100).	
	of rail.	of joint.	30 ft. rail.	60 ft. rail.
Falk joint	·00215	·00355	98	99
Double brazed bond	·00725	.00758	99·8	99·9
Johnson bond	·00364	·00342	95·6	97·8
Plate bond.....	·0109 (2 ft.)	·0233 (6 in.)	89	94

Six hundred amperes can safely be carried by any of the bonds mentioned, and the cost of double bonding should not exceed 3s. per joint, 90 per cent. of the conductivity of solid steel being readily obtainable. It is therefore cheaper to make the return wholly of well bonded steel rails, supplementing the track near the power houses with worn-out rails carefully bonded.

E .H. C.-H.

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527. *Diagonal Rail-Bonding.* (Street Rly. Rev. 8. p. 766, 1898.)—The Harrington Rail-Bonding Co. obtain a large surface for bonds by drilling the holes diagonally where the web and bottom flange meet. With a special drilling machine, the two holes may be drilled, reamed, and the bonds put in place in two minutes. The reamer tapers $\frac{1}{4}$ in. per foot, and the "Columbia Protected" bonds are coned to the same taper. E. H. C.-H.

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528. *Cars for Special Purposes.* (Street Rly. Journ. 14. pp. 704–707, 1898.)—The Nassau Company of Brooklyn have a special car fitted with hydraulic jack, by which the car can be lifted off the rails at a crossing and put on to another track having no connection through points. Also a special tower-car with adjustable platform on roof, enabling repairs to be affected on the "up" trolley wire while the tower-car is on the "down" line. With this car it is possible to string up live trolley wire at the rate of one mile in twenty minutes. E. H. C.-H.

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529. *New Controller.* **J. C. Henry.** (Street Rly. Journ. 14. pp. 433–434, 1898.)—The author appears to separately excite the motors by putting the fields direct on the line, regulation being effected by varying the fields. By so doing, the capacity of the motors is increased. In the usual way about 60 per cent. of the total energy used by the cars is absorbed in getting them under headway. But by the author's method a great deal of this is

saved, no resistance being inserted in the armature circuit; and a further saving of energy is effected by using the motors, which automatically become dynamos, for braking the cars. The method has the further advantage that, as the field is controlled by the line pressure, the speed of the car remains about the same on all parts of the track. In changing from series to parallel, one of the armatures is short-circuited with a resistance. Reversing is effected by the fields. W. R. C.

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530. *Wear of Steel Rails.* **A. T. Moxham.** (Elect. Engin. N.Y. 26. pp. 459–460, 1898.)—Experiments lasting for three years have been made on a "soft" and on a "hard" steel rail, and on a rail both "hard" and "ductile" supplied by the West End Street Railway Company of Boston. Thirty-three rails in all were laid continuously in the South Eighth Street tracks of the Nassau Electric Railroad, Brooklyn. The cars pass this point at extremely short intervals. The percentages of carbon in the soft, hard, and West End rails were 0·280, 0·590, and 0·570 respectively. The specific gravities were 7·956, 7·971, and 7·977 respectively. The tensile strengths were 75,860 lbs., 118,100 lbs., and 120,380 lbs. respectively. The average monthly wears were 0·0017, 0·0012, and 0·0007 inches respectively. On this basis the time taken to wear away $\frac{1}{2}$ in. would be 25 years, 35 years, and 60 years respectively for the soft, hard, and West End rails. The author emphasises the fact that unless the joints be made perfect, there is no need to worry about the quality of the steel; the very cheapest steel that can be bought will last longer than the joints will allow the rails to be kept in the track. A. S.

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531. *Electricity on Torpedo Vessels.* **B. Pontifex.** (Elect. Engin. 22. pp. 455–457, 1898.)—In this paper the features peculiar to the electric lighting of small war-vessels are briefly described and discussed. A. H. A.

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532. *Ship-wiring.* **J. C. Bagot.** (Elect. Engin. 22. pp. 454–455, 1898.) — The author briefly describes the ruling conditions and the methods adopted in installing the electric light on board merchant ships. A. H. A.

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533. *Duflos Arc-Lamp.* (Ind. Élect. 7. pp. 387–388, 1898.)—In this lamp the two carbon-holders are connected by a chain passing over and gearing with a sprocket pinion mounted on an arbor which also bears a large gear-wheel. About the same axis as the gear-wheel there oscillates a frame having two arms. In one of these arms there is pivoted an arbor which bears a pinion gearing with the above-mentioned gear-wheel and also a ratchet- or detent-wheel having long teeth adapted to be brought into and out of engagement with a fixed finger or tooth by the oscillation of the frame. The motion of the said frame is controlled by connecting its other arm, by means of a link, to a pivoted lever bearing the laminated core of the controlling electromagnet (shunt), and also a weight for counterbalancing the moving system. When the magnet attracts its armature, the ratchet- or detent-wheel is moved away from the stop-finger and the carbons are brought together; when the circuit through the carbons is completed, the shunt magnet releases its core and the detent-wheel moves back into engagement with the stop-finger and strikes the arc. By reason of the length of the teeth of the detent-wheel, the stop-finger can enter more or less deeply into the spaces between them, and thus a fine feed is obtained.

C. K. F.

TELEGRAPHY AND TELEPHONY.

534. *Hertzian Telegraphy.* **E. Ducretet.** (Comptes Rendus, 127. pp. 713–716, 1898.)—The author describes the "coherer" system of telegraphy in use since last October between the Eiffel Tower and the Paris Panthéon—a distance of 4 km. The transmitter is the usual form of oscillator, excited by an induction-coil giving a 25 cm. spark. This sparking-distance is diminished considerably when the exploring-wire is connected to the apparatus; the author attributes the diminution to the great capacity of the exploring-wire—the wire is not very far from the metal-work of the tower. The receiver is contained in a portable box at the Panthéon, and means are provided for registering the signals. It is worth noting that although this system works perfectly arranged in this way, it fails when the attempt is made to interchange the sending and receiving apparatus at the two stations, *i.e.*, it fails when the Eiffel Tower is made the receiving station for signals sent from the Panthéon. The case is an extreme one, owing to the large masses of iron and other conducting material in the vicinity. R. A.

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535. *Telephone Distances exceeding the K.R. Law.* **A. E Dobbs.** (Elect. Engin. N.Y. 26. pp. 406–407, 1898.)—The K.R. law does not allow for the good effects of leakage and self-induction, and whereas it states that speech will be indistinct if K.R. exceeds 50,000, the line Boston to Omaha has K.R. =400,000 with clear speech. The test for capacity is taken with open lines, whereas the capacity is in effect reduced by bridging bells. In long lines the disturbances from want of balance tend to counteract each other. A lightning arrester is illustrated. M. O'G.

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536. *Telephone Switchboard at Harlem, N.Y.* (Elect. Engin. N.Y. 26. pp. 512–513, 1898.)—Glow-lamp signals worked by relays give great simplicity. Subscribers have no transmitter battery or magneto. Unhooking a receiver glows a lamp at the exchange and saves time on the ringing method. When the operator plugs into the answering jack the lamp goes out. As long as both subscribers keep their receivers unhooked both lamps are out. When both "hang up" both lamps light, thereby giving a disconnection signal, and the operator need never listen in to know if a conversation is ended. A trunk line uses a red lamp and two white ones. The whole system is admirable from the point of view of supervision. M. O'G.

SCIENCE ABSTRACTS.

PHYSICS AND ELECTRICAL ENGINEERING.

APRIL 1899.

GENERAL PHYSICS.

537. *Vibration of Apparatus.* **A. Broca.** (Journ. de Physique, 7. pp. 648–650, 1898.)—This paper contains a description of some experiments made to determine in how far sensitive apparatus, if placed on rubber blocks, is protected from the vibrations of the building. If the apparatus is of a rigid type, and has no movable parts with natural periods of the order of one second, *e.g.*, a telescope or optical apparatus, the rubber blocks serve as perfect insulators against the vibrations. If, however, the apparatus has a movable system, like a d'Arsonval galvanometer, the vibrations, instead of being diminished by the rubber, are increased, the rubber serving as a flexible support on which the apparatus vibrates with a much longer period; it therefore influences the movable system much more than when the period of vibration is short. The results are similar to those previously obtained by the author (see 1898, Abstract No. 234). J. B. H.

538. *Torsion and Recalescence of Steel.* **G. Moreau.** (Comptes Rendus, 128. pp. 292–294, 1899.)—Beyond a torsion of 58° per cm., the permanent torsion of a steel pianoforte wire varies in proportion to the initial tension T. In wires of different thicknesses, $T - T_r$ is inversely proportional to the diameter, so that for an initial torsion which is sufficiently great one can write—

$$T_r = T - \frac{k}{d}$$

Hence the laws for steel are analogous to those of soft iron, the only difference being that the permanent torsion sets in later in the case of steel. The constant k varies very rapidly in the

neighbourhood of the point of recalescence and of maximum tempering, and thus furnishes a new means of determining these two points exactly. It retains its initial value 0·0056 until 290°, then diminishes up to the temperature of recalescence, 715°, and remains constant after that, at a value 0·0018. E. E. F.

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539. *Ductility of Copper.* **H. Bouasse.** (Comptes Rendus, 128. pp. 291–292, 1899.)—The specimens examined are copper wires newly drawn and those aged by heating to 200° for 1 to 100 hours. The ductility curves are well represented by the formula—

$$p = p_0 + A\sqrt{\log \frac{l}{l_0} - \frac{l - l_0}{l_1}}$$

where p is the pull, l_0 the initial length, l the length on removing the pull, *i.e.*, after deducting the temporary stretching, and p_0, A_1, and l_1 are constants, p_0 being the limiting pull at which permanent stretching sets in. This limit decreases with prolonged heating. If p_1 is the pull given by the above formula for the case of $l = l_1$, which is very near the point of rupture, $p_1 l_1$ is sensibly constant whatever the duration of the ageing process. E. E. F.

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540. *Tidal Analyser.* **R. A. Harris.** (Phys. Rev. 40. pp. 54–60, 1899.)—For the stencil sheets used in the tide summations of the U.S. Coast and Goedetic Survey are substituted a number of cylinders, each representing a single component for, say, a period of 370 days. The circumference of each cylinder is divided into 370 equal parts, each division fixing a line or element which represents a day. The recording or adding apparatus for each kind of summation consists of two series of toothed wheels, all wheels of a series being upon a common shaft; the number of teeth upon each wheel of the first series may be taken as 300, and of the second series 299. The cylinders control the 300-tooth wheels by means of levers, one for each wheel. The twenty-five levers for each component are upon a common axis parallel to the axis of the cylinder. At one end of the lever is a pin or projection for entering the holes in the surface of the cylinder, while at the other end is a sharp edge extending upward for engaging the wheel above, thereby stopping its motion. Since the preventing of a wheel from rotation with its shaft must give rise to friction and wear, it is best to stop but one out of each 25, rather than stop 24 of them. This involves no extra work except the subtracting of the final machine readings from a constant number, the grand total of all hourly heights. E. E. F.

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541. *Molecular Weight and Density of Fluids.* **D. Berthelot.** (Comptes Rendus, 128. pp. 553–556, 1899.)—There is a rigorous proportionality between the molecular weights of gases and their limiting densities at zero pressure. These limiting densities are equal to the product $d\,[1-(A_o^p)_t\,p]$, where d is the density at pressure p and temperature t, and $(A_o^p)_t$ is the coefficient of divergence of gas at t^o with respect to Boyle's law, between the infinitesimal pressure p_o and the experimental pressure p. This expression is perfectly general and applies to all fluids, whether in the liquid or the gaseous state. Applied to liquids, it offers the advantage of connecting their molecular weight and their density, with the aid of the law already applied to gases, that is to say, the Avogadro-Ampère law regarded as a limiting law. It is the most direct method for determining the molecular weight of liquids.

If the characteristic equation of the fluids, $f(p, v, t)=0$, were accurately known, $(A_o^p)_t$ could be calculated, but it is only imperfectly known at present. Still, the formula of van der Waals constitutes a first approximation and gives a network of curves which, without coinciding with those of Amagat, follow their general aspect and characteristics. But the law of corresponding states has a greater generality than even van der Waals' equation. Let p_c, T_c, v_c be the critical pressure, temperature, and volume of a body. If we put $\omega=\frac{p}{p_c}$, $\theta=\frac{T}{T_c}$, and $\upsilon=\frac{v}{v_c}$, the function $\Phi\,(\omega, \theta, \upsilon)=0$ is the same for all bodies, and for very small pressures the characteristic equation tends towards the form $pv=RT$, R being a constant characteristic of the molecular weight of all substances. Calculation shows that—

$$1-(A_o^p)_t\,p=k\,\frac{\omega\upsilon}{\theta}$$

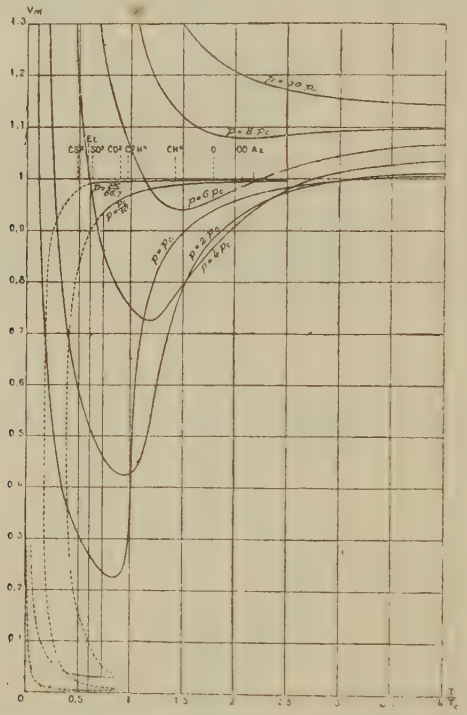
where k is a number. If Φ has the form which results from van der Waals' equation, $k=\frac{8}{3}$.

Hence, if $\frac{1}{v}$ is the density of a fluid at an absolute temperature T^o and a pressure p; if we know its critical pressure p_c and its critical temperature T_c, we are able to calculate its molecular weight. The quantity $1-(A_o^p)_t\,p$ may be represented by v_m, as it is the real volume occupied by 1 molecule of the fluid, the unit being the volume occupied by 1 molecule of the perfect gas under the same circumstances. The result of the calculations from the formula are shown in the diagram.

The molecular volumes v_m are the ordinates, the reduced temperatures $\frac{T}{T_o}$ are the abscissæ, and the curves are traced for different values of $\frac{p}{p_c}$. If Avogadro's law were accurate, we should have $v_m=1$ for all temperatures and pressures. Hence the curves show the divergences from Avogadro's law. The curve $p=p_c$

shows an infinite v_m at the absolute zero of temperature, since there the gaseous volume is infinitesimal and the liquid volume is finite. The curve $p = p_c/66{\cdot}67$ corresponds to most bodies under ordinary conditions.

To compare these curves with experiment, the positions occupied by various bodies at 0° C. are shown. Drawing ordinates through these points, and taking their intersections with the curves, values for v_m at various pressures are obtained. For hydrogen, which is far outside the limits of the diagram, the curve indicates $v_m = 1{\cdot}00014$ and experiment $1{\cdot}00019$. Among



the liquefiable gases, such as C_2H_4, CO_2, and SO_2, the theoretical curve diverges more slowly from the straight line $v_m = 1$ than the real curve. Thus for SO_2 the curve gives $v_m = 0{\cdot}987$, and experiment $0{\cdot}972$. For CS_2 the curve gives $v_m = 0{\cdot}0046$ and experiment $0{\cdot}0031$. In spite of enormous variations of v_m, the theoretical numbers are of the same order of magnitude as the experimental ones. It is clear that the molecular weight of liquids can be calculated to within a few per cent. E. E. F.

LIGHT.

542. *Recorder of Photometric Readings.* **C. P. Mathews.** (Phys. Rev. 7. pp. 239–241, 1898.)—In taking photometric readings it is generally necessary to use some sort of illumination for the scale. This illumination is objectionable, since the sudden influx of light produces in the observer fatigue of the retina and of the pupillary muscles, and there is a consequent loss of visual sensitiveness. Furthermore, when it is a question of the photometry of a fluctuating source, the delay and irregularity of the readings is a drawback.

To remedy these disadvantages the author has used a recording drum. A cylinder of wood 10 cm. in diameter and about 1·5 m. in length is mounted with its axis parallel to and somewhat below the top of the photometer bar. At the end of a spring, attached to the photometer carriage, a steel point projects downward nearly to the surface of the cylinder. A rod extends the length of the cylinder and carries at one end a pawl which engages the teeth of a ratchet-wheel at the cylinder end. The act of sharply depressing the rod advances the cylinder a certain angular amount and punctures the paper by means of the steel point. With this recording apparatus the observer is enabled to take a series of readings and examine them afterwards. W. G. R.

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543. *Source of Luminosity.* **H. Crew** and **O. H. Basquin.** (Amer. Acad. Proc. 33. pp. 337–349, 1898.)—The authors here describe experiments designed with the object of answering the question, "Is it possible by heat alone to obtain the characteristic visible spectrum of a gas?" The electric arc is taken as the source of heat; but to study the thermal effects alone the chemical and electrical effects in the arc have to be separated from the thermal.

An alternating current is used for the arc, and by means of a special rotating interrupter on the alternator shaft all the currents in one direction or the other can be cut off from the arc. During these intervals when no current is passing between the electrodes, the arc is examined photographically and spectroscopically, a disc with suitable holes in it being mounted on the dynamo shaft to serve as rotating shutter to expose the arc at any desired instant during the interruption or at any phase of the current. Calculation and experiment both show that $\frac{1}{1000}$ sec. after the break, self-inductive effects have ceased, so that the electrical effects are then eliminated from the arc.

Electrodes of iron, zinc, and magnesium are used in an atmosphere of hydrogen, to eliminate, if possible, the chemical effects. With iron electrodes a persistent luminosity is observed in the

arc after the current is interrupted, this luminosity being greater in an atmosphere of oxygen than in one of hydrogen. As the jet of hydrogen escaping from the vessel containing the arc is found to burn with a white centre in the flame characteristic of carbon compounds, it is evident that, with the impure iron used, chemical effects are not eliminated. Using electrodes of pure zinc or pure magnesium no persistent luminosity is found. The only light that remains after interruption, apart from that emitted by the red-hot electrode, is a sort of blue haze—a blue glow which fills the whole vessel and is there all the time. This light appears to be exactly the same for all three metals, iron, zinc, and magnesium. It is too diffused and faint to be easily examined by the spectroscope.

In reply to the main question, the authors conclude that on heating metallic vapours to the temperature of the electric arc, they are unable to discover any characteristic spectrum after an interval of $\frac{1}{1000}$ sec. As the form of electrode is, however, favourable to rapid cooling of the vapours, the authors intend repeating the experiments with another form less conducive to the rapid diffusion of the heat. J. B. H.

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544. *Dispersion in a Vacuum.* **L. Décombe.** (Comptes Rendus, 128. pp. 172–174, 1899.)—The author discusses the various astronomical methods available for detecting a possible dispersion in interstellar space, and shows that though the evidence is doubtful, it indicates a possibility of a greater velocity of the violet rays instead of the red. He proposes to make an experiment at two stations, say 9 km. apart, sending simultaneous optical and electromagnetic waves from one station and photographing them at the other by means of a rotating mirror, after converting the invisible wave into a spark or some other visible effect. He maintains that even a very slight retardation could be detected in this manner, and intends to carry out himself the experiment suggested. E. E. F.

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545. *Magnetic Double Refraction.* **A. Cotton.** (Comptes Rendus, 128. pp. 294–297, 1899.)—A sodium flame is placed between the pole-pieces of an electromagnet, and is traversed by an intense beam of white light. A nicol is placed on each side of the flame in the path of the white light, and the two nicols are crossed, their principal planes making an angle of 45° with the magnetic lines of force. The light which reappears on magnetising the electromagnet is studied by means of a Rowland grating. The general rule is that for each of the new rays created by the magnetic field, the flame only absorbs those rays of the white light which it emits itself. If the flame is rich in sodium, each of the D rays becomes a wide doublet with diffuse external boundaries. The components of each doublet are so widely

separated that the distance between the D_2 components may, for instance, attain a quarter of the distance between the two rays. The new rays are also very broad. The author has specially studied the polarisation of the rays from flames rich in sodium by means of a quarter-wave plate. On turning the analyser into such a position as to extinguish an elliptic vibration in the direction of the plane of the incident beam, the continuous spectrum reappeared with the two D lines reversed and broadened. On making the field, the borders of the two rays took up an unsymmetrical aspect. On one side of D_2 there appeared a bright fringe followed by a dark one, while the other border became brighter. Hence the vibrations in the neighbourhood of the rays had become elliptical, right-handed on one side and left-handed on the other, the rule being that for all radiations more refrangible than one of the D lines the component perpendicular to the field was in advance with respect to the other. The inverse was observed to hold good for the less refrangible radiations. This double refraction is connected with the Zeeman effect, and is in accordance with Becquerel's explanation. The vibrations parallel and normal to the field have distinct maxima of absorption, and also distinct curves of anomalous absorption. The rotatory dispersion observed by Macaluso and Corbino is easily accounted for by considering the two inverse circular vibrations. E. E. F.

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546. *Secondary Röntgen Rays.* **G. Sagnac.** (Comptes Rendus, 128. pp. 300–303, 1899.)—The bundle of transformed rays emitted by a body under the influence of Röntgen rays constitutes a mixture of various rays whose powers of penetration, inferior to those of the Röntgen rays which generate them, form a series which is the longer the more profoundly the original Röntgen rays are modified. The heavy metals especially emit very heterogeneous secondary beams. The more easily absorbed rays are absorbed by a few millimetres of the air itself. The author calls the secondary rays S-rays. He describes an interesting experiment made by laying a sensitive film upon a metallic plate exposed to Röntgen rays, and gently inclining the film with respect to the metal. The Röntgen rays, of course, produce a blackening which is uniform all over the film. But where the layer of air between film and metal is not thicker than 1 mm. the blackening is intensified by the action of the S-rays. Quite close to the edge of the film, however, where the thickness of air is not more than 0·1 mm., there is a distinct brightening. The author suspects here the presence of some S-rays capable, like ordinary light, of neutralising the photographic effect of Röntgen rays, and recalls Schumann's discovery of extreme ultra-violet rays of $0{\cdot}1\mu$ wave length, which also possess this property, and are absorbed by a layer of air 0·1 mm. thick. E. E. F.

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547. *Transformation of Röntgen Rays.* **G. Sagnac.** (Comptes Rendus, 128. pp. 546–549, 1899.)—To determine the precise degree of transformation of secondary rays which enter an electroscope, the author employs the method of successive filtrations. The same plate of aluminium, mica, ebonite, or paraffin is first interposed in the path of the incident Röntgen rays and then in the path of the secondary rays. The action of the secondary rays is feebler in the second case, and the time t' necessary for the same displacement of the gold leaf is longer than the time t required in the first case. The co-efficient $c=\frac{t'}{t}-1$ is called the co-efficient of transformation of the rays received by the electroscope. This coefficient varies with the thickness of air traversed, owing to the heterogeneous character of the ordinary Röntgen ray beam. On diminishing the thickness of air a limiting value of the coefficient is reached. The secondary rays emitted by the different metals then show transformation coefficients roughly increasing with the density or the atomic weight. E. E. F.

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548. *Dark Light.* **G. le Bon.** (Comptes Rendus, 128. pp. 297–300, 1899.)—Having proved that bodies exposed for only a few seconds to sunlight retain for several months the power of producing an impression upon a sensitive plate, the author goes on to show that bodies enclosed in opaque boxes can be photographed in a few seconds by using, in the place of a sensitive plate, a plate of phosphorescent zinc sulphide. After exposure, this plate is put into contact with a photographic plate, which is then developed by the usual methods. The source of light is a lamp screened by black paper, which acts the part of a Röntgen tube when the object is photographed by transmission But the object can also be photographed in its box by reflection, as in the case of ordinary light. To render the sulphide screen sensitive, it is exposed for a few seconds to sunlight. It is well known that the rays at the red end of the spectrum have the property of neutralising the phosphorescence produced by the more refrangible rays, and it is just the infra-red rays of a wave length of about $1{\cdot}5\ \mu$ that are most capable of traversing opaque non-conductors such as ebonite, paper, and wood. In studying the physiological effects of the infra-red rays, the ordinary light rays, which neutralise them, will have to be eliminated. This could be done by covering a conservatory with black paper. All the objects inside would be exposed to a kind of invisible but exceedingly active light. E. E. F.

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549. *Source of Uranium Radiation.* **W. Crookes.** (Comptes Rendus, 128. pp. 176–178, 1899.)—The anomaly in the radiation from uranium, thorium, polonium, and radium, the source of which has not yet been discovered, may be elucidated by assuming that these metals have the power of Maxwell's "demon" in being able to separate the rapidly moving from the slow-moving molecules of air, appropriating some of the energy of the former. The energy thus gained seems to be employed partly in dissociating some of the gaseous molecules, and partly in maintaining a radiation across the ether. The necessary smallness and small amplitude of these waves would make them similar in many respects to Röntgen radiation. The air round the Becquerel substance would of course be cooled, but more air would be constantly taking its place. Under ordinary circumstances the cooling is not detected, and the energy of the radiation appears to be created out of nothing. The total energy of the molecules of air in repose at ordinary pressure and temperature is about 180,000 foot-pounds per cubic metre of air. Hence the air contained in a room $4 \times 8 \times 7$ m. possesses sufficient energy to give one H.P. for fifteen hours. E. E. F.

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550. *Residual Luminescence.* **G. le Bon.** (Comptes Rendus, 128. pp. 174–176, 1899.)—Most bodies exposed to light retain the property of emitting obscure radiation, sometimes long after the influence of the light has ceased. The phenomenon is best studied in those bodies which show luminescence under ordinary circumstances. Fifteen days after exposure to sunlight, screens of calcium sulphide are capable of giving sharp prints of negatives with an exposure of twelve hours. The residual luminescence produced by a few seconds' exposure to sunlight requires about eighteen months for its complete dissipation. The author proves, by photographing a statue painted with a luminescent substance by its own obscure radiation, that these obscure rays undergo refraction just like ordinary light. They are also polarised in the same manner. They behave, in fact, exactly as if they were rays of ordinary light, too feeble to make any impression upon the retina. E. E. F.

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551. *Phosphorescence at Low Temperatures.* **A.** and **L. Lumière.** (Comptes Rendus, 128. pp. 549–552, 1899.)—Attempts were made to determine the precise low temperature at which phosphorescent bodies lose their luminosity, to regain it on heating. Specimens of calcium and zinc sulphides exposed to the arc lamp showed an enfeeblement at $-20°$ or $-30°$, and their phosphorescence disappeared entirely at about $-50°$. When exposed to magnesium light, the luminosity disappeared

between $-70°$ and $-90°$. When exposure to magnesium light is made at $-191°$, the temperature of liquid air, and the body is then heated, luminosity begins to appear already at $-180°$, and increases as the heating proceeds. The exciting and emitting processes are thus separated, and by means of rapid heating, it is possible to watch the first stages of phosphorescence, which are usually masked by the incident light. This is specially valuable in bodies whose phosphorescence is of short duration. The neutralising action of the less refrangible rays is the same at low temperatures as at ordinary ones. Röntgen rays act like ordinary light, the phosphorescence produced by them setting in when the body is heated.

E. E. F.

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552. *Phosphorescence of Strontium Sulphide.* J. R. Mourelo. (Comptes Rendus, 128. pp. 557–559, 1899.)—The same sulphide of strontium, obtained by Verneuil's method, will exhibit a brighter and more persistent phosphorescence after exposure to diffused daylight than after exposure to direct sunlight. Repeated short exposures to diffused light also increase the susceptibility of the substance, while repeated exposures to sunlight as a rule diminish it. Iron, heated to a temperature below red heat, is capable of exciting vivid phosphorescence, especially if the powdered substance is placed directly upon it. One phosphorescent substance is capable of exciting another. The author attempts to connect some of his results with Le Bon's "dark light."

E. E. F.

HEAT.

553. *Long Heat-Waves.* **H. Rubens** and **E. Aschkinass.** (Wied. Annalen, 67. 2. pp. 459–466, 1899.)—While quartz in layers a few mm. thick absorbs all heat rays from $\lambda = 4{\cdot}5\,\mu$ to $\lambda = 24{\cdot}4\,\mu$, the residual rays obtained by successive reflection from rock-salt ($\lambda = 51{\cdot}2\,\mu$) and sylvine ($\lambda = 61{\cdot}6\,\mu$) are again transmitted to a considerable extent, but they then show an extreme refrangibility, the index being as high as 2·46 for $\lambda = 51{\cdot}2\,\mu$. Hence a quartz prism furnishes a simple means of separating out these rays from a miscellaneous spectrum, and a plate of rock-salt, which absorbs all heat rays, may be employed to test whether the energy studied contains any such rays. By means of quartz prisms of small refracting angles the authors obtained waves which, measured by the diffraction grating, showed a wave-length of 56 μ at the maximum of energy, and for which quartz had a refractive index amounting to 2·18, in close agreement with the Ketteler-Helmholtz dispersion formula. Attempts to obtain much higher wave lengths failed, owing to the fact that the radiation of an "absolutely black" body beyond 60 μ is less than 1/100,000th of the total energy. E. E. F.

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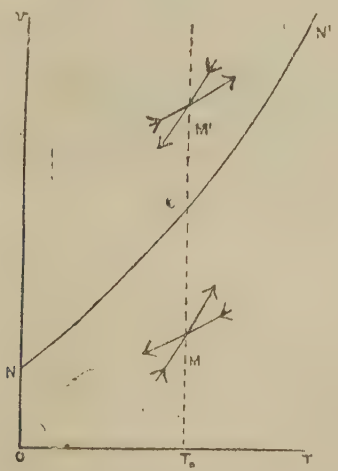
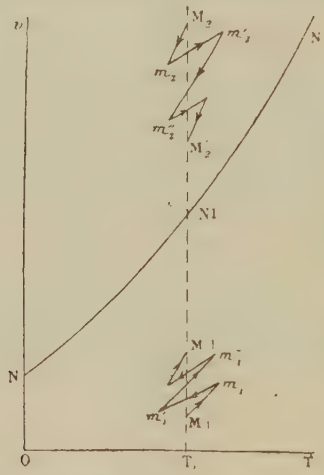
554. *Glass and Changes of Temperature.* **M. L. Marchis.** (Journ. de Physique, 7. pp. 573–591, 1898.)—The author represents the effect of changes in temperature on glass by drawing curves which have temperatures as abscissæ, and specific volumes as ordinates:—



The curve for a rising is different from that for a falling temperature. At a given temperature when the specific volume

is smaller than a certain amount, the ascending curve makes a greater angle with the horizontal than the descending ; whilst the reverse holds for larger volumes. Thus the regions which behave differently are separated by a line which the author calls the line of natural conditions (*ligne des états naturels*). This line is represented in the above figure by NN′. M represents a condition when the specific volume at a temperature T_0 is less than the natural or stable volume ; whilst M′ represents a condition when the volume is greater.

The figure below shows the effect of small oscillations in temperature. It will be noticed that below the line their effect is to increase the volume ; whilst above, the volume is decreased.



The author seems to think that small oscillations in temperature are to a large extent responsible for the gradual approach of the reading of a glass thermometer to a definite value. By means of additional curves the behaviour of glass under various conditions is elucidated ; and their truth is confirmed by experiments on a Guilbert-Martin crystal thermometer. A. Gs.

SOUND.

555. *Velocity of Sound in Air.* **J. Violle.** (Comptes Rendus, 127. pp. 904–908, 1898.)—A discussion of the corrections which must be applied to the experimental value obtained for the velocity of sound on account of the humidity of the air, taking into consideration the different ratios of the two specific heats in the cases of dry air and of water vapour. The author considers Leduc's criticism of the result obtained by himself and Vautier at Grenoble in 1885. J. J. S.

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556. *Loudness of Phonograph.* **Dussaud.** (Comptes Rendus, 128. pp. 552–553, 1899.)—The sound reproduced by a phonograph is louder in proportion to the length of the furrow corresponding to each vibration. It follows that the loudness may be increased either by turning the record cylinder more rapidly while taking a record, or by constructing phonographs with wider cylinders. Further, if one phonograph is made to speak into another moving at a greater rate, or having a larger cylinder, the original sound will be amplified, and this can be carried to any desired extent. E. E. F.

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557. *Radiophony.* **Dussaud.** (Comptes Rendus, 128. p. 171, 1899.) — For the sunlight used in the ordinary selenium cell arrangement the author substitutes ultra-violet light, but he retains the selenium cell, and influences it through the intermediary of a fluorescent screen. The vibrations are imparted to the beam by fixing an additional slit behind the slit in front of the arc lamp, and making the additional slit vibrate at right angles to its length with the sound vibration. Sounds have thus been transmitted to a distance of 10 m. E. E. F.

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558. *Radiophony.* **A. Sella.** (N. Cimento, 8. 4. pp. 261–264, 1898.)—The method employed by the author involves the use of ultra-violet light instead of sunlight. The circuit of a powerful influence machine, without condensers, is closed by a telephone and a short air-gap. When the machine is working, the rapid succession of sparks produces a sound in the telephone. If a beam of ultra-violet light impinges upon the negative terminal of the gap the sound of the telephone is much altered. If the impact of the ultra-violet light undergoes a periodical variation the sound in the telephone will show an alternation of the same period, and if these periodical variations are short enough

combination tones are produced corresponding to the periodical disturbances of the ultra-violet light. On this principle the author constructs an instrument for transmitting sound to a distance. The ultra-violet beam is periodically deflected out of the way by means of a phonautograph mirror, and is finally received upon the flat kathode at the distant station. Greater clearness is obtained by putting the spark-gap in circuit with the secondary of an induction coil, and the telephone itself in the primary. The sound is also heard on putting the ear near the collectors of the influence machine. E. E. F.

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559. *Telephone Experiment.* **A. Sella.** (N. Cimento, 8. 4. pp. 261–263, 1898.)—A telephone in circuit with a spark discharge gives a sound: let ultra-violet light fall on the negative terminal of the spark-gap and the sound is altered. If the ultra-violet light fall periodically a new sound is produced, of the same frequency as the interruptions. The ultra-violet light may be rendered intermittent on the spark-gap by being reflected from a vibrating membrane. The telephone may be put in circuit with the primary coil of an induction coil, the static machine and spark-gap with the secondary; the sound is then very loud and clear. A. D.

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560. *Electrical Transmission of Sound.* **Dussaud.** (Comptes Rendus, 127. pp. 960–961, 1898.)—An invariable note is produced by means of an electrically controlled tuning-fork vibrating in front of a very sensitive microphone. This microphone transmits the note by means of an electric current to a telephonic receiver of new type, including four magnet-poles each acting on a membrane of iron. The air acted upon by the membranes is led into a small resonator of the form and size of the human mouth. Musical sounds and the spoken voice have been transmitted over some distance and made audible throughout a large hall. J. J. S.

ELECTRICITY.

561. *Energy of the Magnetic Field.* **H. Pellat.** (Journ. de Physique, 7. pp. 702–708, 1898.)—Referring to his former paper (Comptes Rendus, 125. p. 699, 1897), in which he had proved that the usual expression for the energy of an electric field requires modification if the temperature is to be constant, M. Pellat now proves the same result for the magnetic field. He considers three cases—(1) in which are concerned only natural magnets; (2) only electromagnets; (3) both. For case 1, all the magnets are assumed to increase in intensity *pari passu*. If U_T be the energy that has to be provided to increase all the magnets from zero to x and maintain the temperature constant, he finds

$$dU_T = \left[\Sigma MV - T\left(\frac{d\Sigma MV}{dT}\right)\frac{x}{M}\right]dx$$

in which V is the magnetic potential, Mx the magnetic charge.

In case 2, the currents all increasing *pari passu*, from zero to x, he finds

$$U_T = \frac{1}{2}\Sigma\left(L - T\frac{dL}{dT}\right)I^2 + \Sigma\left(M_{ij} - T\frac{dM_{ij}}{dT}\right)I_iI_j$$

where $\frac{1}{2}L_1I^2{}_1 + MI_1I_2 + L_2I^2{}_2$ is the usual expression for the energy of two circuits, and ΣL is the sum of all the L's, ΣM_{ij} is the sum of the M's for every pair of circuits.

In case 3, M. Pellat finds that the energy of a field consisting of electric circuits and natural magnets is the energy of the electric circuits in the absence of the magnets plus the energy of the magnets in the absence of the circuits, as Kelvin pointed out many years ago (see also 1899, Abstract No. 318). S. H. B.

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562. *Loss of Electric Charge by Evaporation.* **H. Pellat.** (Comptes Rendus, 128. pp. 169–171, 1899.)—A definite proof is furnished that electrified water loses part of its charge by evaporation. The author studied the loss of charge from a system comprising a very flat dish, either empty or full of water, and a quadrant electrometer. The charge was imparted by a battery giving 116 volts. Without water, the loss amounted to 170·4 scale divisions in 105 minutes. With water it was 182·9 divisions in the same time. The twenty experiments gave very concordant results. The author applies them to explain the daily variation of atmospheric electricity after sunrise and sunset, but admits that the maximum at 8 p.m. and the minimum at 4 a.m. are not explained yet. E. E. F.

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563. *Electrical Discharges.* **J. Trowbridge.** (Amer. Acad. Proc. 33. pp. 435–452, 1898.)—The author gives an account of his experiments in which air and other gases are subjected to powerful electrostatic stress (see also 1899, Abstract No. 281.) The additional points which may be noted in the present paper are the following conclusions of the author :—

1. When the initial resistance of highly rarefied air is broken down by means of Röntgen rays, it exhibits less resistance than it does at 2 mm. pressure, when it is generally considered to have the maximum conductivity.

2. There are anode Röntgen rays as well as kathode Röntgen rays, and these rays exhibit all the peculiarities of the kathode rays; such as the excitation of fluorescence, and the peculiar action of breaking down the initial resistance of air and other gases.

3. Röntgen rays can be distinctly produced with an E.M.F. of 10,000 volts, and there are indications of them at a pressure of 5,000.

4. Electrostatic induction is an important phenomenon in that of Röntgen rays, the mechanism of their production being a setting up of electrostatic lines of induction along which the E.M.F. acts, and the production of an electromagnetic wave or impulse. The stress in the medium reduces its initial resistance, and the Röntgen rays' radiation becomes less and less energetic after a certain interval the longer the Crookes tube is excited, for the increased conductivity of the medium persists after each impulse of such radiation, and therefore the difference of potential between the terminals speedily drops, or does not rise to the full value which the induction machine is capable of developing.

5. The behaviour of highly rarefied media to powerful electric stress is analogous to that of elastic solids to mechanical stresses. The generation of Röntgen rays is accompanied by a powerful electrostatic stress which breaks down the so-called elasticity of the medium. J. J. S.

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564. *Continuity of Vacuum Discharges.* **M. Cantor.** (Wied. Annalen, 67. 2. pp. 481–484, 1899.)—Under certain conditions, vacuum discharges can be obtained which are apparently continuous. But their apparent continuity may be due to the fact that the instruments employed are not sufficiently sensitive to discover any discontinuity. The author has, therefore, tested the matter with the aid of the coherer. He placed a battery of 1,000 accumulators in the cellar, and connected it by thick copper wires with the laboratory on the second floor. On joining the kathode of the vacuum tube with the leaves of an electroscope, and through a liquid resistance with its metallic case, the form of discharge described by Hertz was found to be apparently continuous, since the electroscope showed no divergence. But,

under the same circumstances, a coherer filled with small iron screws showed the presence of waves distinctly. A number of controlling experiments, undertaken to eliminate sources of error, led to the same result. It remains now to discover whether the wave system is superimposed upon a continuous substratum, or whether the discharge is entirely discontinuous. E. E. F.

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565. *Anode Rays.* **A. Broca.** (Comptes Rendus, 128. pp. 356–358, 1899.)—The author mounts two pointed electrodes of platinum, 2 mm. thick, in the centre of a spherical vacuum bulb, and surrounds the stems of the electrodes with glass tubes. The distance between the points is only half a millimetre. With a sparking distance in air of about 12 cm., a very small and very brilliant spark is obtained at every discharge. After some time, a small crater is formed in the anode, resembling the crater formed in a positive carbon. This distinctly proves the discharge of some material particles, and thus furnishes another proof of the emission theory. Ordinarily, whatever material disintegration there is is found in the kathode. But that is simply due to the fact that in the ordinary tubes the potential gradient is steepest at the kathode. In the spherical tubes described the potential gradient is uniform, and the metal, being electropositive, naturally escapes from the anode. That it is projected with considerable force is shown by the fact that no metal is deposited on the kathode, but that it goes to the glass wall. When the bulb is introduced into a magnetic field, the "anode rays" are deflected in a sense opposed to the deflection of kathode rays. They also show a left-handed screw motion where the kathode rays show a right-handed twist. E. E. F.

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566. *Canal Rays.* **A. Wehnelt.** (Wied. Annalen, 67. 2. pp. 421–426, 1899.)—When a cross of mica, fastened to a small piece of sheet-iron, so as to shift it with a magnet from outside, is placed within the dark kathode space of a vacuum tube, a shadow of the cross, somewhat hazy and magnified, appears on the kathode. The size of the shadow is independent of the distance between the cross and the kathode, as long as the cross remains within the dark space. The shadow is equally unaffected by a change of pressure, or the substitution of a cross of different material. It is evidently produced by the stoppage of positive particles moving towards the kathode, and these same particles, when they penetrate gaps in the kathode, give rise to the so-called canal rays. The canal rays are probably identical with the luminous layer which immediately adjoins the kathode. The positive or anode rays produce oxidation, and the author has succeeded in forming a permanent silhouette of the cross upon a

copper kathode in the usual colours of oxidised copper, the succession of tints at the half-shadows being the same as that seen on a copper plate unequally heated. E. E. F.

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567. *New Wave Detector.* **A. Neugschwender.** (Wied. Annalen, 67. 2. pp. 430–432, 1899.)—A narrow gap is scratched into the coating of a silver-on-glass mirror, and the mirror is inserted into the circuit of a Daniell cell and a galvanometer. On breathing upon the mirror, the condensed vapour bridges over the gap, and the galvanometer shows a deflection. But this deflection is immediately annulled when electric waves impinge upon the mirror. When a piece of moistened cloth is fixed near the mirror, the action is rendered continuous. Every train of waves produces an infinite increase of resistance while it lasts, and on its cessation the normal current is re-established. The gap in the mirror must be so wide, of course, that no ordinary coherer action intervenes. A good width is 0.3 mm. The experiment also succeeds with copper or tin as a mirror metal (though not with platinum), and with glass, mica, celluloid, caoutchouc, stearine, or pitch as a support. Ammonia, HCl, and various salt solutions may be employed, but no effect is produced unless the liquid is so far evaporated that nothing can be seen of it with the naked eye. Sound vibrations, concussions, statical charges and simple heating are without effect, but every spark discharge is instantly responded to. The response is so rapid that the individual discharges of an induction coil are separately indicated, as may be proved by inserting a telephone in the detector circuit. E. E. F.

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568. *Measurement of Electric Waves and their Absorption by Water.* **A. D. Cole.** (Phys. Rev. 7. pp. 225–230, 1898.)—These experiments were devised in order to determine the absorbing power of water for electrical radiations of wave-length ranging round 10 cm.

The liquid was placed in glass cells of different thicknesses and interposed in the path of the radiation so that its absorption might be observed. However, the observations were complicated by the fact that the path through the cell was comparable with the wave-length in the liquid, as was clearly shown by the results obtained. No attempt was made to deduce the absorption from the observations by means of the theory of thin plates of absorbing media. A thermo-junction was used in connection with the receiver, and worked satisfactorily. The radiator was a modified Righi exciter. F. T. T.

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569. *Hertzian Field in Air and in Water.* **A. Turpain.** (Comptes Rendus, 127. pp. 955–957, 1898.)—With reference to his former experiments on air and oil (see C. R. 126. p. 1630, 1898), the author gives here the result of his measurements in the case of air and of water. He deduces the following experimental laws:—

1. The wave-lengths of the electric oscillations which excite a given resonator, placed in his "position II" are the same in air and in the dielectric.

2. For the oscillations which excite the resonator in the "position I," the ratio of the wave-length in air to the wave-length in a dielectric is equal to the square root of the specific inductive capacity of the dielectric.

The number obtained for this ratio in the case of air and water varies with different resonators from 7·0 to 8·5. J. J. S.

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570. *Electromagnetic Waves near Wires.* **A. Sommerfeld.** (Wied. Annalen, 67. 2. pp. 233–290, 1899.)—The author studies the propagation and distribution of a periodic and harmonic electrodynamic disturbance in the vicinity of an infinite straight wire. He finds that the differential equations for the electric and magnetic components inside and outside the wire are easily integrated, and lead to Bessel functions. On excluding the possibility of a propagation exceeding the velocity of light, and unaccompanied by damping—a possibility which would suppose an unknown radial supply of energy from infinity—the surface conditions furnish a transcendental equation whose root determines the wave-length λ and also the speed of propagation λ/τ of the wire wave, as well as the constant of local damping κ in the complex formula $(2\pi/\lambda) - i\kappa$. The discussion of this transcendental equation makes it necessary to distinguish two chief cases, accordingly as the number ρk is large or small. The number ρk is defined by $k = 2\pi\sqrt{C\mu/\tau}$, where C is the conductivity in electromagnetic measure, μ the constant of magnetisation, τ the duration of oscillation, and ρ the radius of the wire. The number is usually large for metallic conductors, especially if the oscillation is not too slow nor the wire too thin. In both cases the very complex original equation may be much simplified by a rapidly convergent solution. In the case of a large ρk the solution corresponds with the generally accepted views of the nature of wire waves. The divergence of the propagation from the velocity of light is very small, and so is the damping of the wave in its progress along the wire, and it is the smaller the larger the value of ρk. Thus in the case of a copper wire 4 mm. thick and a frequency of 10^9 per second it appears that the wire wave lags behind light only by about 8 km. per second, and is damped to the eth part of its value only after covering 1·5 km. of its path. But in the second case the deviation from the velocity

of light and the damping may be very considerable. Thus in a platinum wire 0·004 mm. in diameter and with a frequency of 3×10^8 per second the speed is only three-quarters of the rate of propagation of light, and the damping is so strong that it reduces the amplitude to its eth part within a distance of only 17 cm.

There is, of course, a continuous transition between cases 1 and 2. The distribution of the electric and magnetic forces in the two cases agrees with the current views in case 1, and disagrees with them in case 2. In case 1 the forces diminish rapidly from the surface inwards. The whole process, in so far as it has not descended below the hundredth part of the surface intensity, is confined to a layer of the thickness $4{\cdot}6/k$, *i.e.*, in the copper wire mentioned, in a layer of thickness less than 0·01 mm. Outwards, the forces diminish rather slowly. In the interior, the electric lines of force are nearly tangential; outside they are nearly normal to the wire surface. But in case 2, owing to the thinness of the wire, the surface layer cannot freely develop itself. Outside the wire, the lines of force are not even approximately normal to its surface.

The author proceeds to point out what outstanding questions remain to be answered.

In the first place, while the present investigation deals with a single infinite wire without return circuit, the practical arrangement used consists of two parallel wires joined by a bridge. It is probably very difficult to determine mathematically the effect of this device upon propagation and damping. The nearest approximation to the actual case would probably be obtained by ascribing a parabolic curvature to the infinite wire. Then we should have either a single wire or two parallel wires according to the size of the parameter of the parabola.

The position of the source of the waves, a free end of the wire, or a resonator introduced into the field would produce disturbances not considered in the author's theory. Also, instead of a periodic harmonic disturbance, the generation of a steady electric current may have to be contemplated. Liquid conductors would also create new conditions, but the present theory would apply to wires surrounded by a dielectric different from air. E. E. F.

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571. *Dielectric Constant of Stretched Indiarubber.* **O. M. Corbino** and **F. Cannizzo.** (Roma R. Accad. Lincei. Atti, 7. pp. 286–292, 1898.)—A sheet of red caoutchouc, under varying degrees of tension, forms the dielectric of a condenser the capacity of which is compared with a second condenser whose capacity can be varied at will. A special determination shows that Poisson's ratio equals 0·42; and after applying corrections, the authors find that the dielectric constant diminishes with increase of tension. The way in which its value varies, within the limits examined, is indicated by the equation $\kappa' = \kappa (1 - A\lambda)$; where κ is the

dielectric constant when the caoutchouc is free from load, and κ' is the dielectric constant when the elongation per unit length is λ. Also $A = 0{\cdot}64\ (\kappa - 1)$. A. Gs.

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572. *Dielectric Strength.* **T. Gray.** (Phys. Rev. 7. pp. 199–209, 1898.)—Circular transformers giving 100,000 volts were used with a choking coil to prevent short circuits. The pressure was inferred from a Kelvin voltmeter on the primary. The terminals were polished spherical surfaces of 35 cms. radius.

It was assumed that the effect of a thick continuous dielectric could be obtained by superimposing several sheets. The following results were obtained:—

Material.	Maximum Dielectric Strength in Kilovolts per centimetre.
Glass	285
Hard rubber	538
Soft rubber	476
Soft rubber, second quality	492
Mica	2000
Micanite	4000
Papers paraffined:	
Manilla wrapping	430
American linen	540
Blotting felt	150
Fuller braid	295
Empire cloth	310
Empire paper	450
Lubricating oil	48
Linseed oil	83
Cotton seed oil	67
Air, 0·02 cm. between plates	57
Air, 1·6 cms. between plates	27

M. O'G.

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573. *Electrical Properties of Vapours from the Carbon Arc.* **E. Merritt** and **O. M. Stewart.** (Phys. Rev. 7. pp. 129–148, 1898.)—The vapours from a carbon electric arc are conveyed to a charged brass cylinder, and its rate of loss of charge measured by means of a quadrant electrometer. The results of the experiments are:—

1. The vapours from the carbon arc possess the power of discharging electrified bodies with which they are brought into contact. In general the electrical properties of these vapours are similar to those of gases that have been acted on by Röntgen rays, or to gases from a flame. Except at low potentials the rate of discharge is not proportional to the potential, but approaches a limiting value as the potential of the charged body is raised.

2. This discharging power is retained even after the vapours have been passed through long tubes of glass or metal, and lasts for at least ten seconds.

3. When caused to pass between a charged conductor and one that is earthed, the vapours lose most of their conducting power. A similar result is obtained by passing the vapours through loosely packed asbestos wool.

4. After passing between two earthed conductors only a short distance apart, the vapours are found to discharge a negatively electrified body more rapidly than one charged positively. In this respect their behaviour is similar to that of gases that have been ionised by the action of Röntgen rays. The explanation is probably that suggested by Zeleny, viz., that the negative ions diffuse more rapidly than the positive ones.

5. Positive and negative charges are in general dissipated by the vapours with equal rapidity. Experiments made with a vertical enclosed arc, however, show that gases taken from near the lower carbon have unequal discharging powers for the two electricities; in this case the charge which is of the same sign as the lower carbon is dissipated less rapidly. This is true whether the lower carbon is positive or negative; and the effect is not altered by connecting either carbon to earth.

6. If air or oxygen that has been saturated with water vapour is introduced into the enclosure containing the arc, the conducting power of the arc vapours is greatly increased. This effect, however, can no longer be observed when the body to be discharged is at a considerable distance from the arc. E. C. R.

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574. *Electric Conductivity and Luminosity of Flames.* **A. Smithells, H. M. Dawson,** and **H. A. Wilson.** (Roy. Soc. Proc. 64. pp. 142–148, 1898.)—No general consensus of opinion appears to exist as to the mode by which the metal of an alkali salt is liberated when the salt is vaporised in a flame. By some the liberation is supposed to be effected thermally by chemical dissociation; others suppose that the salt is converted into hydrate or oxide, and then reduced by the flame gases. It is also noteworthy that however the metal be liberated and however oxidisable it may be, light is emitted from parts of the flame where oxidising gases are in abundance, and where even less oxidisable metals in the massive state are rapidly oxidised. The objects of the experiments described is to ascertain whether the luminosity imparted by vaporised salts to flames is related in a definite manner to the electrical conductivity of the salt vapours. The apparatus employed is essentially the arrangement used by one of the authors (Smithells, Phil. Mag. 39. p. 122, 1895) in other investigations of flame, whereby the two cones that constitute the flame of a Bunsen burner can be separated widely and

maintained apart for any length of time. The authors conclude from their experiments :—

1. That the conductivity of vaporised salt is of an electrolytic character, but that there are features connected with it that distinguish it from electrolytic conduction in aqueous solution. Thus Ohm's law is only obeyed within certain limits, and the general relation between current strength and electromotive force can only be represented generally by a more complex expression.

2. The conductivities of different salts differ greatly according to the electropositive constituent.

3. Among different salts of the same metal differences of conductivity appear at the higher concentrations, but at low concentrations equivalent solutions have equal conductivity.

4. The conductivity of the haloid salts as a group is distinct from that of the oxy-salts.

5. The conductivity of the haloid salts of a metal among themselves increases with the increasing atomic weight of the halogen.

6. The conductivity of the oxy-salts of a metal is approximately equal to and approaches, that of the hydrates.

7. The more easily oxidisable halogen salts are probably partly converted into oxide in the flame, so that their conductivity is composed of two parts.

8. The behaviour of the salts in flames supplied with chloroform vapour seems to establish the fact that the conductivity and the colour produced by the salt vapour are not due to a common cause. J. J. S.

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575. *Thomson Effect in Copper.* **R. O. King.** (Amer. Acad. Proc. 33. pp. 353–379, 1898.)—The object of this investigation was the determination of the Thomson Effect in copper in absolute measure and its variation with temperature.

The copper bar experimented with was heated by an electric current, while its two ends were kept at a constant temperature by water circulation. A descending temperature gradient and consequent flow of heat were therefore established from the centre of the bar towards both ends. Owing to the electric current being against the flow of heat in one half of the bar, and with it in the other, the temperature of one half of the bar gained at the expense of the other, due to the Thomson effect. By reversing the current and measuring the rise or fall of temperature at different points along the bar, the Thomson effect was calculated from the data obtained.

The temperature distribution along the bar was determined by measuring (by a potentiometer method) the electrical resistances of successive short lengths of the bar when heated, the resistances of these same sections at ordinary temperatures and the temperature coefficient being known. Separate experiments were made

with the bar heated by different currents to determine the heat lost by radiation and convection from the different sections of the bar. The heat lost from a section by conduction could be calculated from the conductivity and the temperature gradients at its ends.

The results of one set of experiments are :—

$\theta = 166°$ C.	$\sigma = 608 \times 10^{-8}$	Calories	per	sec.
$\theta = 183°$ C.	$\sigma = 606 \times$ „	„	„	„
$\theta = 197°$	$\sigma = 566 \times$ „	„	„	„
$\theta = 208°$	$\sigma = 508 \times$ „	„	„	„

The results show a diminution of the Thomson effect with increase of temperature, and are therefore not in accordance with Tait's assumption that it is proportional to the absolute temperature. It is therefore inadvisable to deduce values of the Thomson effect for other metals in the customary way. J. B. H.

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576. *Measurement of High Resistances.* **J. Schürr.** (Journ. de Physique, 7. pp. 598–602, 1898.)—The method consists in determining the damping of the oscillations of a d'Arsonval galvanometer when on open circuit and when shortcircuited by the unknown resistance. Resistances varying from 4,800 to 800,000 ohms are measured with an accuracy of about 1 per cent. Specific resistances of electrolytes are also determined by this method. J. B. H.

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577. *Resistance of Moving Electrolytes.* **E. H. Hall.** (Phys. Rev. 7. pp. 246–247, 1898.)—In *Il Nuovo Cimento* for April, 1877, Bosi describes experiments which appear to show that a very moderate velocity of an electrolyte in the direction of, or contrary to, the direction of an electric current through it, makes a considerable change, increase or decrease, according to conditions, in the electrical resistance of the electrolyte.

Last year a student of the author's repeated this experiment in a slightly modified manner, and concludes that Bosi's conclusions are incorrect. W. G. R.

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578. *Polarisation and Internal Resistance of Cells.* **K. E. Guthe.** (Phys. Rev. 7. pp. 193–198, 1898.)—The author investigates the apparent variation of internal resistance with generation of current in a primary cell, or passage of current in a voltameter. Wiedeburg's theory of polarisation is the one which

gives the best representation of the facts. His formula for the polarisation of a voltameter is as follows :—

$$p = \frac{P_1}{2}\left(1 - e^{-\frac{\beta_1}{s_1}q}\right) + \frac{P_2}{2}\left(1 - e^{-\frac{\beta_2}{s_2}q}\right)$$

in which P denotes a limiting value, β a constant, s_1, s_2 the surfaces of the electrodes, and q the quantity of electricity that has passed. This theory demands a curve for internal resistance decreasing with increasing currents ; for if the experiments are carried out with equal intervals of time, the above gives rise to the following equation :—

$$\rho - r = \frac{P}{I}\left(1 - e^{-K_1}\right)$$

in which ρ is the apparent resistance, r the actual resistance, and I is the current. By using the pendulum apparatus previously used by Carhart for the determination of E.M.F. and potential difference on closed circuit (and thence the internal resistance), the author determines the value of ρ in a copper voltameter for various currents. These decrease with increasing current, as already shown by previous investigators ; but the values of r, or the true internal resistance, deduced from these are constant.

W. R. C.

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579. *Polarisation Capacities.* **A. M. Scott.** (Wied. Annalen, 67. 2. pp. 388–420, 1899.)—The author completes his researches on the polarisation of thin metallic membranes, and studies the influence of electrolytic polarisation upon apparent capacity, and the influence of pressure upon polarisation capacities. His results enable him to declare that all polarisation phenomena in thin gold membranes are due to pores in the metal, whose existence may be demonstrated. In the platinum membranes employed no pores could be found, and no depolarisation was provoked by an alternating current. The polarisation capacity of platinum, he concludes, is determined by occluded gases, and depends upon the condition of the platinum. Gold and aluminium show a similar behaviour under kathodic polarisation, and show an increase of capacity with E.M.F. Under anodic polarisation an insulating layer is produced on the aluminium, whereas gold goes slightly into solution at higher E.M.F.'s. The polarisation capacity of silver and lead is affected by the metallic ions in the electrolyte. The hydrogen ions have no appreciable influence. Under kathodic polarisation, mercury has a minimum polarisation capacity at an E.M.F. corresponding to the difference of potential between the mercury and the electrolyte, but solutions showing an abnormal behaviour as regards

maximum surface tension also show abnormal results with regard to minimum polarisation capacity. External pressure has no influence upon polarisation capacity. E. E. F.

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580. *Polarisation of thin Metallic Foil.* **G. P. Grimaldi** and **G. Platania.** (Atti del Acc. Givenia de Catane, 10. 4, 1897, and Écl. Électr. 17. pp. 211–214, 1898.)—The polarisation of thin sheets and of foil is studied by means of a pendulum charger and discharger. The time of charging is obtained from the length of the pendulum. The sheets of polished gold have a thickness of 0·09 mm. The gold foil has a thickness of 10^{-4} mm. Equal areas are exposed. The following table gives the mean results for a great number of experiments.

	E.M.F. of Polarisation.		
Time in Seconds.	Sheet.	Foil.	Ratio of Sheet to Foil.
0·0022	0·045	0·033	1·36
0·0047	0·084	0·068	1·23
0·011	0·170	0·139	1·22
0·021	0·260	0·224	1·16
0·054	0·434	0·377	1·14
0·147	0·546	0·526	1·03
0·295	0·606	0·605	1

S. S.

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581. *Temperature Coefficient of the Potential of the Calomel Electrode.* **T. W. Richards.** (Zeitschr. Phys. Chem. 24. pp. 39–54, 1897, and Amer. Acad. Proc. 33. pp. 3–20, 1897.)—The calomel electrodes are united by various supernatant electrolytes, so as to form systems of the general form Hg—HgCl—MCl—HgCl—Hg. One calomel electrode is maintained at a low temperature, and the other warmed to various temperatures. The potentials are compensated on a Poggendorff potentiometer using either a sensitive galvanometer, or a Lippmann capillary electrometer. The results of the experiments are :—

(*a*) The temperature-coefficient of the potential of the calomel electrode increases with the dilution of the electrolyte.

(*b*) The kation of the electrolyte influences the result by affecting the degree of ionisation of the chloride in solution.

(*c*) Both these effects may be approximately computed by a simple logarithmic formula based on Nernst's hypothesis.

(*d*) The accuracy of the results is affected by the catalytic decomposition of mercurous chloride into mercuric chloride and mercury.

(*e*) This decomposition is responsible for the slight inconstancy of the normal calomel electrode.

(*f*) The "decinormal" electrode is more constant than the normal.

(*g*) HCl and NH_4Cl are anomalous in their behaviour.

S. S.

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582. *E.M.F. of Clark and Cadmium Cells.* **S. N. Taylor.** (Phys. Rev. 7. pp. 149–170, 1898.)—The author finds that cadmium cells are as easy to construct as Clark cells, and arrives at the result that

$$\frac{\text{Clark cell at } 15^\circ}{\text{Cadium cell at } 21{\cdot}7^\circ} = 1{\cdot}4077.$$

Absolute measurements were also made, by means of a dynamometer, of the E.M.F. of the Clark, but the results appear to be of no value. W. R. C.

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583. *Jacques Cell.* **J. W. Langley.** (Frank. Instit. Journ. 146. pp. 224–234, 1898).—The author gives curves showing the variation of E.M.F. with temperature. As the latter rises, the E.M.F. falls, and *vice versâ*. Experiments were carried out with copper and iron (with and without air blast) in place of the carbon, but the results were much the same as when carbon was used. Sodium nitrate around the carbon, in place of air, diminished the E.M.F. The author concludes in favour of a thermoelectric origin of the E.M.F. W. R. C.

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584. *Electrolytic Contact Breaker.* **A. Wehnelt.** (Elektrotechn. Ztschr. 20, pp. 76–78, 1899.)—Starting from the well-known fact that a current passing through a liquid between two electrodes of very unequal area is capable of producing luminosity on the smaller electrode, and that these luminous effects show signs of intermittence, the author determined whether there was a true interruption of the current, or only a variation between a maximum and a minimum value. He inserted a lead plate and a platinum wire into a beaker filled with dilute sulphuric acid, the platinum electrodes being held by a glass tube filled with mercury, with its end bent towards the lead plate. He found that such a cell, with the wire as anode, acts as a very perfect interrupter with a frequency of about 1,000 per second, giving sparks 40 cm. long with 6 amperes and 12 volts. A condenser is superfluous, and there is no need to eliminate self-inductions. The latter indeed are, on the whole, beneficial. The interruptions occur with remarkable regularity, as indicated by the pitch of the note emitted. E. E. F.

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585. *Electrolytic Contact Breaker.* **d'Arsonval.** (Comptes Rendus, 128. pp. 529–532, 1899.)—The author confirms all the results stated in the preceding abstract, and adds some valuable observations of his own. With 70 volts he obtained from an induction coil sparks in the shape of a continuous stream of fire 25 cm. long, and of the thickness of a pencil. The frequency, as determined by means of a revolving mirror, was 1,700 per second With a small coil of only 4 cm. spark length the frequency was over 3,000 per second. The frequency depends upon the self-induction of the coil, the size of the platinum wire, and the E.M.F. of the current. A wire 0·7 mm. thick, projecting about 2 cm. from the glass tube, gives good results. With such a wire the author excited a Crookes tube and obtained Röntgen rays of a steadiness and penetrating power far beyond the usual. A radiograph of the hand was instantaneous. Employed with one of the author's medical apparatus of high frequency, the new interrupter gave results at least ten times as strong as those obtained with the Foucault interrupter. When an alternating current is substituted for the continuous current, the coil works equally well, and, what is very important, it lights up the Crookes tube just as in the case of the continuous current, which proves that the interruptions take place in only one direction. The new interrupter is therefore also a current separator. Hence, in radiography, the same work can be done whether the current available is continuous or alternating.

In conjunction with a Berthelot effluviator, the coil gives quantities of ozone incomparably greater than the ordinary spring interrupter. Regular and powerful Hertzian waves may also be obtained, and wireless telegraphy is thereby greatly facilitated. The interruption curve, traced with an Abraham rheograph, is very regular, and shows no traces of parasitic oscillations or idle time. The best form of interrupter hitherto obtained consists of a test tube with the platinum wire introduced through the bottom. Potash may be substituted for the dilute acid, and iron for the lead. The following is the author's theory of what takes place: By the passage of the current the platinum point is brought to a white heat. Thereupon the liquid is heated, and forms a layer of non-conducting vapour round the platinum, thus interrupting the current. Then the vapour condenses, the current recommences, and the process repeats itself. This view is supported by the fact that when the liquid is hotter than 90° the vapour is no longer condensed, and the interrupter does not act. There is also an evolution of an explosive mixture of hydrogen and oxygen, due to the white-hot platinum. This also explains why the interruption takes place only in one sense; for when the platinum point is positive it heats up quicker than when it is negative. To fully utilise the valuable properties of the coherer, the induction coil will have to be modified as regards shape, dimensions, and nature of insulator. Since high frequencies are at work, it is better to have a liquid, or at least a pasty insulator. E. E. F.

586. *Electrostatic Voltmeter.* **A. Perot** and **C. Fabry.** (Journ. de Physique, 7. pp. 650–659, 1898.)—This voltmeter, which is designed as a standard, is of the attracted disc type. The suspended system consists of an equilateral triangular plate of glass silvered lightly on both sides. It is suspended between two equal fixed triangular plates of glass, these two plates being separated from each other by glass pieces at the three corners, the movable plate being turned through 60° in azimuth to clear the separating pieces. The surfaces of the fixed plates facing the movable plate are lightly silvered and the top plate is electrically connected with the movable one. A beam of white light is sent through the three plates, and if the thicknesses of the two air films differ little, the system of "interference fringes of superposition" is seen. By means of these fringes the position of the suspended plate can always be recognised and when attracted towards the bottom plate by a difference of potential between them it can always be brought back to the same zero position by extending the central spring which, together with three other springs, carries it. The amount of extension of this spring gives the attracting force, but as the difference of potential is proportional to the square root of the attraction, a mechanical system of links connects the end of the spring with a pointer, which moves a distance equal to the square root of the extension of the spring.

The instrument constructed had the top plate slightly convex on the silvered side to give a circular form to the fringes. It measured from 20 to 70 volts with an accuracy of 0·1 volt.

J. B. H.

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587. *Combined Ammeter and Voltmeter by General Electric Company.* (Electrician, 41. pp. 677–679, 1898.)—This instrument is of the round dial form, and is primarily a galvanometer of the d'Arsonval type, having its coil pivoted and controlled by two springs, by means of which current is led into and out of the coil. Used as a galvanometer, a current of 0·00004 ampere is easily measured, so that with a constant potential of 200 volts, insulation resistance can be tested up to 5 megohms. Larger currents and also pressures are measured by using a shunt and series resistance.

W. G. R.

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588. *Condenser Losses.* **E. B. Rosa** and **A. W. Smith.** (Phys. Rev. 8. pp. 1–20, 1899.)—The enormous discrepancies between the results of measurements previously made with a view towards determining the numerical value of the energy lost in condensers led the authors to measure this energy loss in such a way that it could be expressed absolutely. They measure by means of a wattmeter the energy dissipated in a condenser when it is subjected to an alternating E.M.F. In order that the

frequency of charge and discharge be perfectly definite, the E.M.F. should be a simple harmonic one, that is, the upper harmonics of the fundamental should be absent. This is most easily effected by inserting in the circuit in series with the condenser a coil of wire having large self-induction but without an iron core. The variable permeability of the iron gives rise to upper harmonics, especially if the magnetic induction of the core attains larger values, and hence a coil without an iron core is necessary. The best value for the self-induction of the coil is such that the fundamental is reinforced to a maximum degree, in other words, it is the value of L given by the equation

$$t = 2\pi\sqrt{LC}$$

There is another practical advantage resulting from this arrangement, namely, that the resulting resonance raises the E.M.F. at the terminals of the condenser very greatly, thus saving the necessity of raising the pressure by transformers. And a third advantage now appears in the fact that the wattmeter may be inserted across the low pressure supply wires to measure the total power expended upon coil and condenser. Then subtracting the I^2r loss of the coil, the remainder will be the power expended upon the condenser. This supposes, of course, that there is no iron core, and no eddy current loss in the copper coil itself. The

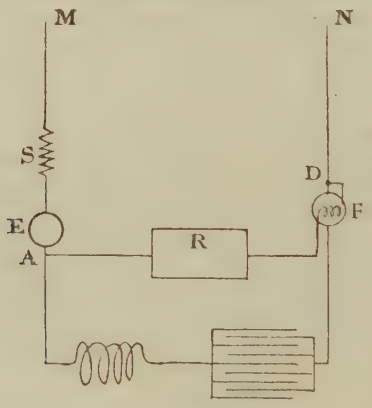

diagram shows the connections for the resonance method employed by the authors. M N are the low pressure supply wires of an alternating circuit, S is an adjustable resistance, E is a dynamometer, F a wattmeter, R a non-inductive resistance in shunt with the coil and condenser, joining the points A and D. The wattmeter, therefore, measures the power expended between the points A and D, including the I^2r_w loss in the fixed coil of the wattmeter, but not including the i^2R loss in the shunt resistance R. The energy expended in the resonance coil and the fixed coil

of the wattmeter, subtracted from the total power measured, leaves the condenser loss. This remainder is found to be also proportioned to the square of the current. Hence we may write it $I^2 r_s$, and r_s is the "equivalent resistance" of the condenser, which it is desired to find. This does not indicate the nature of the process by which energy is dissipated in a condenser, but simply that for a given condenser made of a given dielectric, at a given temperature and frequency, the heating effect is the same as though there were a certain resistance r_s in series with a perfect condenser of the same capacity.

Experiments with a tinfoil and paraffined paper condenser of 0·8 microfarad capacity, with a current of 1·2 amperes and a frequency of 145 gave 23·45 watts for the condenser loss, which is, however, rather too large on account of the eddy current loss in the resonance coil, although the latter had no iron core. Some extraordinary results were obtained with some commercial condensers of $\frac{1}{3}$ microfarad, made with melted beeswax and resin. The loss in the condenser was as high as 26·5 watts at 30°. The loss at 36° C. was 50 per cent. greater than at 30°, and approached a maximum at that temperature. At 47° C. the loss had decreased from 9 to 8 per cent. of the total, and at 49·5° C. to 6·5 per cent. No further readings were taken until the condensers had risen several degrees, when it was suddenly noticed that one pair was hotter than the others, and getting soft. The loss was very large, but the condenser had not broken down, and the leakage current had not greatly increased. These observations were fully confirmed by a totally different method, which consisted in measuring the heating effect by a specially constructed calorimeter.

E. E. F.

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589. *Condenser Losses.* **E. B. Rosa** and **A. W. Smith.** (Phys. Rev. 8. pp. 79–94, 1899, and Phil. Mag. 47. pp. 232–236, 1899.)—The authors' resonance method of measuring the energy dissipated in condensers subjected to an alternating E.M.F. is not sufficiently delicate to give accurate values in the case of paraffined-paper condensers. The same authors have, therefore, constructed a special calorimeter for the purpose of measuring the total quantity of heat produced in the condensers. Tests made with a number of Stanley paraffined-paper condensers showed that they could easily stand 500 volts alternating E.M.F., as indicated by the makers; but that the loss of energy in the condensers could not be calculated, and varied in different specimens within wide limits. At a frequency of 140 per second, the smallest loss observed was 0·74 per cent. One lot of condensers gave a nearly uniform loss of 1·5 per cent., while another lot went as high as 10 per cent. on high frequencies. In beeswax-and-resin condensers the loss was 6 or 8 per cent. As in the experiments with the resonance method, the energy loss was found to be highest at 40° C., and that temperature also repre-

sented the maximum for residual charge. The authors maintain that the singing or hissing of a condenser is not connected in any way with its efficiency. E. E. F.

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590. *Effects of Prolonged Heating on Magnetic Properties of Iron.* **S. R. Roget.** (Roy. Soc. Proc. 64. pp. 150–156, 1899.) (See 1898, Abstract No. 948.)—This paper contains an account of further experiments on this subject, the results being extended to temperatures up to 700° C. The baking was carried on in a specially constructed electric oven heated by coils of platinum wire wound on a mica frame. The temperature was read direct on a Callendar-Griffiths platinum pyrometer. The initial rise of hysteresis was found to be more rapid, the subsequent fall to take place sooner, and the final state to be one of lower hysteresis, the higher the temperature. Great differences of behaviour were observed among different specimens, and some of the brands examined were practically of non-ageing quality. The author sums up the chief effects of prolonged heating on the magnetic properties of iron thus :—

1. Material in the annealed state is more liable to change than in a harder state.

2. All the changes produced by prolonged heating are completely removed by reannealing.

3. The heating need not be continuous; the same cumulative effect is produced by a number of short periods at a given temperature as by continuous heating at the same temperature.

4. The liability of the material to increase in hysteresis at moderate temperatures is not removed by prolonged heating at high temperatures.

5. The change is confined to the lower part of the B-H curve, the upper part remaining unaltered.

6. The effect is produced equally, whether the iron is or is not exposed to the air during heating. A. H.

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591. *Standard Representation of the Magnetic Qualities of Iron.* **H. Kath.** (Elektrotechn. Ztschr. p. 407, 1898, also Écl. Électr. 17, pp. 69–70, 1898.)—The author considers that the magnetic qualities of any kind of iron are sufficiently represented by :—

(*a*) A magnetisation curve of virgin iron for strengths of the magnetising field, H, varying from O to 150 c.g.s. units, or for steel up to 300 c.g.s. units.

(*b*) A hysteresis curve for values of H between $H = +150$ and $H = -150$ c.g.s. units, or for steel between $H = \pm 300$ c.g.s. units.

The scales should be 1 mm. = 100 c.g.s. for B and 2 mm. = 1 c.g.s. for H. W. G. R.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

592. *High Vacua by Liquid Hydrogen, with their Spectroscopic Examination.* **J. Dewar.** (Roy. Soc. Proc. 64, 231–238, 1899.)—Calculating from Willard Gibbs' formulæ, at the temperature of boiling H (35° abs.), the vapour pressures in mm. should be for nitrogen 0·0015, for oxygen 0·000076, as a *maximum*, equal to a tension for O of one ten-millionth, and for N of one 500,000th, of an atmosphere. Thus by means of liquid H, as good an exhaustion should be attained as by boiling out a space with mercury, and with much greater rapidity. The same conclusion is derived from the molecular latent heats of H and O. Figures are given of apparatus by which this result was successfully achieved, with the precautions for excluding or recognising impurities. The incondensible residues from air were examined for the author by Liveing and Crookes, and the lines of neon, helium, and in one case hydrogen, were identified. By means of liquid H, the yellow line of neon 5849 can be detected in 25 c.c. of ordinary air. The presence of free H in the air is a question for further inquiry.

S. R.

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593. *Retention of Gases by Metallic Oxides.* **T. W. Richards.** (Amer. Acad. Proc. 33. pp. 399–426, 1898.)—A continuation of the author's research in the same journal (26, p. 281) on the influence of time and temperature on these phenomena in the case of Zn and Cu oxides. For the thermometric measurements the method of standard melting-points is adopted, and a table is given of these values as found by Carnelley, Le Chatelier, Meyer, and Ramsay, with the results selected as probable. The oxides had been prepared from the nitrates, and it has long been known that the gases result from the decomposition of traces of undecomposed salt remaining in the substance. The heating was carried out in platinum crucibles in a simple furnace described, and the oxides afterwards dissolved in acid in a bulb apparatus figured in the previous paper, the gases being collected and measured over boiled water. In the case of the cupric oxide it was confirmed that it contained 4 to 5 vols. of occluded gas, which was nearly all retained up to 860°, at which point more than $\frac{9}{10}$ was rapidly set free. Above this the CuO commences to decompose, and at about 1,000° fuses into a mixture of CuO and Cu_2O. Prolonged ignition below 450° does not affect the amount of gas retained. At the higher temperatures the oxygen escapes more rapidly than the nitrogen. ZnO behaves similarly, but the O_2 is less readily evolved. Determinations of the conductivity proved that CuO is slightly dissociated at a red heat, ZnO less, and MgO

scarcely at all; hence it is necessary when absorbing O_2 by hot copper to keep the temperature moderate. Incidentally the author discusses the frequent presence of H_2 in CO. S. R.

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594. *Isothermal Pressure-surface for a Mixture of Two Single and One Resulting Double Salt.* **F. G. Donnan.** (Journ. Phys. Chem. 2. pp. 417–420, 1898.)—This surface for temperatures in the region of complete stability of the double salt appears to be saddle-shaped, and its discussion shows that the phenomena of isothermal evaporation can be very fairly well considered by means of it alone. R. E. B.

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595. *Conductivity of Solutions of Double Salts.* **J. G. MacGregor** and **E. H. Archibald.** (Phil. Mag. 46. pp. 509–519, 1898.)—The authors calculate the conductivities at various dilutions of a mixture of potassium sulphate and copper sulphate in such proportions as to be equivalent to the double sulphate. They find that the calculated values agree with those obtained by experiment for a solution of the double salt up to a concentration of about 0·1 gramme equivalent per litre, but at greater concentrations the double salt has an appreciably smaller conductivity than the equivalent mixture. This is not the case in a mixture which does not give rise to a double salt. The smaller conductivity is therefore evidence of double-salt molecules in solution. W. R. C.

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596. *Electrolytic Estimation of Lead.* **A. Hollard.** (Bull. Soc. Chim. [iii.] 19. p. 911, and Écl. Électr. 17. pp. 566–569, 1898.)—As the result of careful study of the precautions which it is necessary to observe in the accurate estimation of lead, it is found that closely coherent deposits, having exactly the composition PbO_2, are obtained by electrolysis for 24 hours with a current of 0·45 ampere between platinum electrodes. The solution, measuring about 350 cc., should contain 80 cc. of free nitric acid and not more than 0.2 gram of lead; it is important that the deposit should be dried at 200°. The process is applicable, with slight modifications, to the estimation of lead in its alloys with zinc, tin, and copper, but not to those containing antimony. N. L.

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597. *Electricity as Applied to Metallurgy.* **R. Threlfall.** (Australian Mining Standard, 12/8/97. Elect. Rev. 44. p. 397, 1898.) —The latter journal publishes an abstract of a long article by Threlfall upon the theory and practical applications of electro-metallurgy. The practical portion of the article is stated to be somewhat out

of date, but the theoretical part is interesting by reason of the presentation of Threlfall's own views upon electrolytic dissociation. He does not consider that it is yet proved that "ionisation" of a dissolved salt carries with it the electrostatic charging of the "ions"; and he inclines to the belief that such charging of the "ions" only occurs when they are engaged as carriers of a current through the solution. His arguments in support of this modification of the generally accepted theory, will be found stated at length in the original.

The practical portion of the article deals with the following industrial applications: Electro-plating, copper extraction, zinc extraction, copper refining, silver refining, soda and bleach manufacture, and the production of hypochlorites, aluminium, and calcium carbide. J. B. C. K.

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598. *The Electro-Chemical and Electro-Metallurgical Industries in* 1898. **J. B. C. Kershaw.** (Elect. Rev. 44. pp. 42–43; pp. 107–108, 1899.)—The writer refers to the chief events of 1898 in connection with these industries generally, and then deals with the progress of the more important branches of industry.

Alkalies and Bleach.—The Greenwood process, and its trial at Winsford, the Rhodin Cell litigation, the growth of the Castner Kellner Works at Weston Point, and the proposed new works for operation of the Hargreaves-Bird process in Cheshire, are referred to. The writer states that the German companies are showing the greatest activity, and it is as a result of their rapid development that Germany is now exporting large quantities of bleach.

The number of electrolytic alkali works in operation at the end of 1898 is estimated to have been 14; while 11 additional works are in course of construction, and will commence to manufacture during 1899.

Aluminium.—The progress in this industry is slow but steady. A new process, the Péniakoff process, is on trial at Selzaete in Belgium. During 1898 aluminium has been used for reducing refractory oxides, and as an electrical conductor for long distance transmission schemes. Each of these new uses may become of industrial importance. The rise in the price of copper is increasing the prospects of success, as regards the latter use of aluminium. Eight works, all operated by water-power, with an aggregate output of 25,000 lbs. of aluminium per day, were in operation at the end of 1898.

Calcium Carbide.—This has been the most active of these new industries during 1898, but the writer considers this activity is premature, and that financial losses will ensue. The number of carbide factories in operation at the end of 1898 is estimated at 32; and 19 additional factories are to be put in operation during the present year. During 1898 the Bullier carbide patents have been declared void in Germany; while litigation over the

Wilson patents has entered upon its preliminary stage in this country.

Copper.—The leading feature of 1898 in this industry is stated to have been the depletion of stocks, and consequent rise of price. The writer estimates that the production of electrolytic copper in Europe in 1898 amounted to between 25,000 and 30,000 tons; and that the total output of the European and American refineries was 170,000 tons. English refiners have suffered from scarcity of supplies; but recent changes in smelting charges will, it is hoped, remove this difficulty. The number of electrolytic refineries in operation in 1898 is stated to have been 36. Three new refineries were in course of construction in America, and will come into operation during 1899.

Chlorates.—This electro-chemical industry is not yet represented by a manufactory in this country; but it is stated that during 1899 one will commence operations in the Midlands, using coal as a source of power. The cause of the delay has been the absence of large water-powers, and the fear that steam-power would prove too costly. The writer states that the number of works engaged in this manufacture abroad is 7; the aggregate H.P. in use is 30,000; and the annual output of chlorates is about 6,500 tons.

Hypochlorites.—The use of hypochlorite solutions for bleaching purposes is extending, and many works on the Continent now possess their own electrolytic bleaching plants. The Kellner, Corbin, and Vogelsang forms of apparatus are stated to be in use. A trial of one of these electrolysers is likely to occur in this country during the present year. The experiments with the Hermite process of sewage treatment at Bombay have failed, owing to the excessive cost. The writer states his opinion that the success of the bacterial method of sewage treatment will render further competition of electro-chemical methods hopeless.

Ozone.—The year 1898 has not witnessed much progress in the industrial application of ozone. The experimental trials of the Tindall-Schnelle method of water purification still continue at Oudshoorn, and Blankenberg; but cost details are lacking. The Rosenblum-Varnold process of thickening and bleaching oils, has yielded successful results; but there is some delay in floating the company, which is to carry on this process on a large industrial scale.

Zinc.—The writer states that the chief event of 1898 in this industry has been the definite abandonment of the Ashcroft process, after lengthy trials at Newcastle, N. S. Wales. The Hoepfner and the Dieffenbach processes are, therefore, now the only two electrolytic zinc processes in operation upon a commercial basis. The joint production of these processes in 1897 is estimated to have been 2,200 tons. The Cowper-Coles and the Nahnsen processes are being worked experimentally, in Cornwall and in Silesia respectively.

The writer believes with others that the refractory sulphide ore

problem will be solved by a fusion process, and on this account calls special attention to the Swinburne and the Fry processes. The former is now on experimental trial in London; the latter is to be worked in 1899 upon an enormous industrial scale at Manchester. The Swinburne process depends upon the electrolysis of a fused bath of sulphides and chlorides; the Fry process is wholly metallurgical in character.

As regards electro-galvanising, the writer states there is nothing new to report. AUTHOR.

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599. *Cleaning Metallic Surfaces by Electrolysis.* **C. F. Burgess.** (Elect. World, 32. pp. 445–447, 1898.)—In this article the author discusses the various methods of cleaning metallic surfaces by electrolysis, and states that the most advantageous arrangement, except when it is required to remove thin coatings of metal, is to make the metallic object to be cleaned the kathode in a strong NaCl or NaHO solution, using a carbon anode. By this means, both chemical compounds of the metal and grease, oil, and other foreign substances are removed without affecting the metallic object itself, since any oxide, sulphide, chloride, or similar compound will be reduced by the Na or nascent H, whilst the oil or grease will be saponified by the NaHO. With a greasy iron surface and a nearly saturated solution of NaCl, and 20 A. per square foot, time required = 15 min.; 40 A. per square foot, time = 3·5 min; 140 A. per square foot, time = 0·75 min. With a KHO solution, a current density of 80 A. per square foot cleaned the iron almost instantly. With a current density of 40 A. per square foot, at 5 volts, the cost of power for cleaning is about 0·06 cent per square foot, assuming power at 4 cents per H.P. hour. Paint, lacquer, enamel, &c., can be similarly removed. C. K. F.

GENERAL ELECTRICAL ENGINEERING.

600. *Accumulators for Auto-cars.* **J. Reyval.** (Écl. Électr. 17. pp. 313–317, 407–410, and 545–547, 1898.)—The author describes, with diagrams, the construction of the Fulmen accumulator (see 1898, Abstract No. 965), the Faure-Sellon-Volckmar accumulator, and the accumulator constructed by the *Société anonyme pour le travail électrique des métaux*. Tables are given of the specific constants of these different types. N. L.

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601. *Zinc Accumulators.* **G. Pellissier.** (Ecl. Électr. 17. pp. 341–345, 1898.)—Twelve watt-hours per kg., including acid and ebonite case, is the highest figure given by any European or American maker of accumulators. Riker is therefore trying cells with lead positives and zinc-coated copper negatives. They give a mean E.M.F. of 2·3 and a maximum of 2·5 volts, and a battery weighing 345 kg. (inclusive) has a specific energy of 36·4 watt-hours per kg. for ten hours, or 29·15 watt-hours per kg. for four hours. E. H. C.-H.

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602. *Fulmen Accumulators and Motor Cabs in Paris.* **E. Hospitalier.** (Soc. Int. Elect. Bull. 15. pp. 275–326, 1898.)—The Fulmen cell used by all the cabs were found to be as follows:—

6 positive plates having 135 grms. of lead and 340 grms. of paste each.

7 negative plates having 135 grms. of lead and 255 grms. of paste each.

21 square decimetres of positive plate.

The containing vessel and separators weigh 600 grms.

The total weight of the accumulator and liquids is $7\frac{1}{2}$ kilogrms.

Normal discharge 21 amps. for 5 hrs.; mean voltage 1·9.

Details and diagrams of all the cabs are given as well as daily expense of current. (See also 1898, Abstract No. 965.)

M. O'G.

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603. *Long-Schattner Electrolytic Prepayment Meter.* (Elect. Rev. 43. pp. 771–773, 1898.)—This is an electrolytic meter in which a copper anode plate is suspended from one arm of a balance-beam, this arm also bearing boxes for receiving coins or standard weights to replace coins, and a bridge-piece forming part of a mercury-cup switch; the other arm of the balance-beam bears a counterweight. The mercury in the cup at which the circuit is broken is covered with a layer of creosote oil, producing a perfectly

sparkless "break" and "make" even at full load. The copper sulphate solution is of 1·115 sp. gr. and made up with 1 per cent. of H_2SO_4 and 99 per cent. of H_2O, evaporation being prevented by a thin layer of ordinary machine oil. The depositing cell is arranged as a shunt to a resistance in the main circuit, and the mercury cups of the switch are connected through a high resistance so that, when an amount of copper equivalent to the weight of the coin inserted has been removed by the current from the anode, the bridge-piece will break the connection at one of the cups; the lamps, however, will not go out, but will burn dim, being supplied through the above-mentioned resistance; the current so used is paid for out of the coin next introduced. One copper plate and box will last for 700 units and then has to be replaced by a fresh plate and box at a cost of 5s. The meter is in use at Norwich. C. K. F.

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604. *Compensating Frictional Resistance in Siemens Electric Meter.* (Zeitschr. Elektrotechn. Wien. 16. pp. 431–433, 1898; German Patent, No. 98211.)—This meter has an annular core with four inwardly directed polar extensions, a drum-shaped copper armature and an internal core, all these parts being somewhat similar to those shown in the diagram on p. 64 of this volume of SCIENCE ABSTRACTS. In the present case, however, the pole-pieces have no lateral extensions and the series coils are wound on one pair of the diametrically opposite pole-pieces, whilst shunt coils are wound on the remaining two diametrically opposite pole-pieces, 90° difference of phase being produced in any suitable manner between the shunt current and the main current. In order to compensate for the frictional resistance to rotation of the armature, a suitable number of turns are wound around one of the quadrantal sections of the core, this coil being arranged as a shunt to a suitable resistance in the main circuit. This produces a weak additional or superposed turning-moment on the armature of the required amount. C. K. F.

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605. *American Lightning Arresters.* **H. E. Raymond.** (Amer. Electn. 10. pp. 497–501, 1898.)—This is an illustrated article containing a descriptive, but not comparative, account of various types of American lightning arresters for both direct and alternating current circuits. In describing the Wurts arrester the author quotes some of the results obtained by Wurts on non-arcing metals. The principal non-arcing metals are zinc, cadmium, mercury, antimony, bismuth, and their alloys or amalgams. W. G. R.

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606. *Electric Alarms.* **J. Ebel.** (Elect. Rev. 43. pp. 649–651, 1898.)—This article describes two inexpensive forms of ordinary electric bells in which a straight electromagnet core has a laterally extending pole-piece at each end, one of which serves as a base and the other is provided with a bracket for the spring bearing the armature, contact-piece, and hammer. Another arrangement is dust-proof and water-tight, this being obtained by arranging the parts within a box having a diaphragm against which the hammer strikes. A closed-circuit differentially-wound burglar-alarm is also shown and described, together with a special form of alarm suitable for large sizes, in which a solenoid is employed having a reciprocating core controlled by a helical spring and moving on balls arranged in longitudinal grooves therein; in this case, the circuit is completed and broken at the calling station. C. K. F.

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607. *Electrically Driven Turntable.* (Elect. World, 32. p. 401, 1898.)—In this turntable, the table platform is supported on two longitudinal girders resting on an equalising drum which turns on a set of rollers. The 15-H.P. motor is series-wound and arranged with its armature-shaft in a vertical position, this shaft being connected, through double-reduction gearing, with a shaft bearing at its lower end a pinion engaging with a circular stationary rack. The table can be turned through an arc of 180° in half a minute, the current (30 A.) being cut off when the table has moved through about 30° or 35°. The cost per month, including attendance (2 men), current, and 10 per cent depreciation on electrical equipment only, is 310 dollars (?). C. K. F.

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608. *Effect of Fire-damp on Incandescent Lamp Filaments.* **H. Couriot** and **J. Meunier.** (Comptes Rendus, 127. pp. 559–561, 1898.)—The authors introduced an explosive mixture of fire-damp and air (9·5 per cent of methane) into the bulbs of electric incandescent lamps either before or during incandescence of the filament, so as to reproduce the conditions which sometimes obtain when the lamps are used in coal-mines. Lamps of from 15 to 110 volts and differents currents (up to 2·15 A.) were experimented with, and it was found that, *with none of the lamps in which the filaments were not previously broken, was there produced an explosion of the most explosive gaseous mixture.* In general the incandescence rapidly diminished save at one point (the upper part) of the filament, which retained its brightness and at which the rupture took place with a small spark after about a minute, the broken ends of the filament being reduced to fine points. There was no different effect produced when the filaments were overrun. The authors remark that the results obtained are in accordance with the fact discovered by them

(Comptes Rendus, 126. p. 752), that incandescent metal wires are incapable of detonating the most explosive mixture. In the present experiments the fire-damp burned quietly without flame and, after the cooling of the lamp, drops of condensed water from the combustion were found on the wall of the bulb. The remaining gas turned lime-water milky and could not be ignited by a match, thus accounting for the harmlessness of the spark on rupture. The authors, however, succeeded in producing an explosion on jolting a lamp, the filament of which had previously been broken; even in this case, the first sparks did not produce any effect. C. K. F.

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609. *Electrically Driven Shipyard Tools.* **F. von Kodolitsch.** (Cassier, 14. pp. 488–498, 1898.)—This article gives short descriptions and photographs of electrically driven boring machines, a bolt-hole reaming-machine, key-cutting machine, punch, tube-expander, crane, winch, portable fan, pump, saw, cylinder-boring machine, lift, and capstan. C. K. F.

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610. *Electric Dumb Waiters in the Chicago Public Library.* (Elect. Engin. N.Y. 26. pp. 329–330, 1898.)—This is a detailed account of the motor-driven dumb waiters at the Chicago Public Library. These waiters are capable of handling 10,000 to 12,000 books per day. W. G. R.

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611. *Electric Cranes at Southampton Harbour.* (Electrician, 42. pp. 123–125, 1898.)—This article describes three 3-ton cranes and a combined 3-ton and 12-ton crane constructed by Stothert and Pitt, of Bath. Photographs and several scale drawings of various parts are given in the original paper. C. K. F.

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612. *Electrical Refrigeration.* **T. F. Fay.** (Elect. Engin. N.Y. 26. pp. 331–332, 353–354, 378–380, 1898.)—These articles discuss the arrangement of electric motors for driving refrigerating machinery and give particulars and drawings of several installations of this kind; the relative advantages of ammonia, sulphur dioxide, Pictet fluid (SO_2+a small percentage of CO_2), carbon dioxide, methylic ether and chymogene are also set forth. The average cost of 1 ton of ice using electric motors, assuming power at 5 cents per kilowatt, and that 1 kw. hour for 24 hours will be

24 kw. hours at 0·05	$1·20
1440 gallons of water	·15
Oil, inspection, &c.	·15
	$1·50

C. K. F.

613. *Erecting a High Pressure Transmission Line.* **S. H. Dailey.** (Amer. Electn. 10. pp. 454–455, 1898.)—This is a third article (see 1898, Abstracts 1095 and 174) on the practical erection of a high pressure transmission line and contains instructions regarding the erection of the poles, with a list of the necessary raising tools. W. G. R.

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614. *Electrolysis of Cast-Iron Pipes.* **H. P. Brown.** (Elect. Engin. N.Y. 26. pp. 441–442, 1898.)—In this paper, read before the American Society of Municipal Improvements, Washington, the author states that cast-iron pipes are usually but little affected by electrolysis since the coating of adherent moulding sand and tar paint protects them. In the ordinary soil, an iron pipe submitted to electrolytic corrosion is covered with a layer of iron oxide, which is a poor conductor of electricity, so that, with a given pressure, the deeper the layer of rust the slower is the rate of corrosion. In the case of cast-iron pipes at Dayton, Ohio, the surrounding soil seems to give a different reaction when a current passes through it. The tar appears to give no protection whatever, and the surface of the pipe is changed into a soft black material resembling graphite, and easily cut with a knife. The chemical analysis of the pipes shows that the percentage of iron is greatly diminished while the percentage of carbon is more than doubled.

The author recommends the use of wooden pipes in districts covered by electric mains. W. G. R.

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615. *By-Products of Power Plants.* **M. M. Fenner.** (Elect. Engin. N.Y. 26. pp. 334–337, 1898.)—The author describes a method of utilising exhaust steam for the heating of buildings, which has been successfully adopted by the Dunkirk and Fredonia Railroad Company. The supply mains consist of an iron pipe to convey the steam, wrapped in asbestos. This is placed on rests 1 inch high within bored logs, the bore being 2 inches greater than the diameter of the pipe so as to give 1 inch of dead air round the pipe; the log has a shell 4 inches thick, waterproofed and lined with tin, the whole being wrapped with three-ply tarred roofing felt and laid on boards at the bottom of a 5-foot trench; expansion joints in brick chambers are provided where necessary. About one mile of these mains has been laid by the company. The most economical steam pressure for heating purposes has been found to be from 4 to 6 lbs., the circulation being maintained by draft from condensation. The condensed water is collected from the pipes into cooling coils, and after losing nearly all of its heat passed into the sewers.

The author estimates that the exhaust steam from a 100-H.P. engine will efficiently heat 1,000,000 cubic feet of space in average

buildings in the severest weather. During hours of light load on the engines the exhaust steam can be supplemented by live steam from the boilers without pecuniary loss.

The steam is supplied by meter and has formed a valuable addition to the company's revenue. M. G. W.

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616. *Electric Canal Haulage.* **A. H. Allen.** (Electrician, 41. pp. 851–853, 1898.)—The decay of the vast system of canal communication in England is due chiefly to the slow speed of transmission as compared with that of railways and coasting steamers, and the heavy charges for tolls and for towing. The method of hauling in general use remains the same as it was a century ago—by horses. Steam tug-boats have been tried, but have not proved satisfactory. The subject of this paper is an adaptation of electrical traction to canal haulage, with a view to accelerating the speed and at the same time reducing the cost —the two most important considerations in connection with goods traffic. The system described by the author is the outcome of long study on the part of Messrs. Thwaite and Cawley, their aim being to provide an economical and efficient method of haulage, which can be applied to any canal without in the least interfering with the use of horses—thus enabling the latter to be dispensed with by degrees if desired. The author describes several methods of electric canal haulage in use at the present time.

In the system under consideration the motors are made entirely independent of the barges, the latter being hauled by means of ropes, exactly as with horses ; in this way the waste of energy incurred with a screw propeller is almost entirely obviated. An ærial railway is provided consisting of two steel rails of channel or Z section, braced together at one side so as to form a rigid girder, and supported at a height of 9 or 10 feet above the towing-path by means of cast-iron brackets or wooden posts at intervals of about 30 feet. Each of these rails constitutes a running track for a number of electric locomotives, each consisting simply of an electromotor mounted on a four-wheeled carriage ; two of the wheels run upon the upper surface of the rail, supporting the weight of the locomotive, and two run beneath the rail, bearing against the lower surface in such a way as to ensure the stability of the locomotive. The motor shaft carries at each end a worm gearing with a worm wheel on each of the four axles, so that all the wheels are drivers ; the gearing runs in an oil bath, and can be so designed as to give an efficiency of 90 per cent. Automatic lubrication is provided for all the working parts, so that frequent inspection is not necessary.

The motor itself is of the ordinary direct current series-wound

traction type. The tractive force required to tow a barge carrying 100 tons on a canal of ordinary cross-section at the rate of 2½ miles per hour, is from 250 lbs. to 300 lbs. The maximum brake horse-power at full speed is therefore 2-B.H.P. To the lower side of each rail is bolted a continuous creosoted wood batten, which supports the electrical conductor, the latter being thus protected from the weather and from mechanical injury.

It is arranged that the two rails form an "up" line and a "down" line, so that the locomotives run on the upper rail in one direction, and on the lower rail in the opposite direction.

The locomotive is controlled entirely from the barge, no driver being required. When starting up to a speed of 4 miles an hour, the current at 500 volts would not exceed 14 to 15 amperes. So that elaborate switching apparatus is not necessary.

The considerations as to position and arrangement of generating stations are fully gone into.

In order to illustrate the economic possibilities of the system, estimates have been prepared of which the following are the results in brief :—

	Cost per ton mile.	Time occupied in transit.
Haulage with horses at 2½ miles per hour.	0·077d.	15 hours.
Electric Haulage at 2½ miles per hour...	0·032d.	12 hours.
Electric Haulage at 4 miles per hour ...	0·041d.	7½ hours.

The electrical system of haulage possesses the following advantages among others: — The boats require no attention whatever. The delays in passing incurred with horse haulage are obviated. Bridges and tunnels cause neither difficulty nor delay. No time is lost in waiting for a train of barges to be loaded, as is the case with steam. Power can be supplied to private consumers, &c., at a low rate. The cost of haulage is reduced by 50 or 60 per cent; and the time occupied in transit by 20 to 50 per cent. as compared with horse haulage. In case of frost, the standing expenses are much less than with horses.

L. J. S.

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617. *Electric Traction on Canals.* **Van der Wallen.** (Bull. Ass. Ing. El. Liège, 9. pp. 309–406, 1898.)—The author reviews the whole subject of mechanical traction on canals, and after dealing with funicular haulage in detail, discusses (1) haulage by mechanical means from the towing-path; (2) propulsion by portable apparatus placed on board the barges. On the Burgundy Canal the Galliot system is in use; an electric tricycle is propelled along the towing-path by a 6-kw. motor, receiving energy from a suspended trolley wire, and hauls barges by means of a tow-rope. The tricycle weighs two tons, and tows a train of barges loaded

with 700 tons at about 1¼ miles per hour. The power required is as follows :—

Load.	Speed.	Power.
387 tons	1·25 miles per hour	3·45 kilowatts
186 tons	1·37 do. do.	1·8 do.
Tricycle alone...	3·75 do. do.	0·9 do.

Lamb proposes to use a telpher line, consisting of two overhead insulated cables, upon which runs a suspended motor hauling the boats with a tow-rope. Various types of rudder-motor propellers are described, and the use of accumulators is discussed. On another part of the Burgundy Canal the Bouguié system of chain haulage is employed; in this case energy is supplied by means of two trolleys and trolley wires to a motor carried on the barge, which drives the chain-hauling gear. The average cost is 0·67d. per ton, as compared with 0·98d. for steam haulage, for the journey of 3·75 miles (of which two miles are in a tunnel).

The author gives details of the process of estimating the power required for electric traction, and discusses the relative advantages of direct and polyphase currents for power transmission, preferring the latter system. The paper concludes with a summary in which the shape of the barges and of the section of the canal are discussed, and the various systems are compared with one another and with animal haulage with regard to fixed and running costs and volume of traffic. A. H. A.

GENERATORS, MOTORS, AND TRANSFORMERS.

618. *Dynamo Design.* **C. P. Poole.** (Elect. World, 32. pp. 555–557, 1898.)—Five years ago the author published a method, then in use by himself, the object of which was economy in time in making preliminary calculations for the dimensions of dynamos and motors. Since then the method has been modified to make it applicable to standard practice in designing, irrespective of personal preferences as to minor details.

The "method" consists in basing the calculations for output upon the peripheral velocity, air-gap density, and number of conductors, and in adopting at the outset fixed values for the peripheral velocity, air-gap density and proportion of armature covered by the pole-pieces for each line of machines of a given type. A number of formulæ are given and analysed, and examples worked out.

The author also gives a formula which should prove convenient for arriving at the necessary coil space on the field-magnet cores:—

$$\sqrt{\frac{V\ At}{\theta \delta G 10^4}} \times d_1 = L$$

Where L represents the length along the core in inches; d_1, the diameter of the wire over the insulation in mils.; δ, the depth of the winding in inches; G, the perimeter of the coil in inches; and θ, the rise in temperature, Fahr.; At, the number of ampere turns; and V, the pressure at the terminals of the field coil. The result cannot be absolutely accurate, because the "imbedding" of the wires of each layer between those of the layer below, which varies with each size of wire, renders it difficult to obtain on paper the exact value of δ. If the coefficient of shrinkage due to "imbedding" be ascertained experimentally for each size of wire, δ can be given a precise value. L. J. S.

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619. *Tests of Rushmore Multi-Circuit Dynamo.* **E. J. Murphy, jr.,** and **P. E. van Saun.** (Amer. Electn. 10. pp. 494–497, 1898.)—The authors give the details of a test of a Rushmore multi-circuit dynamo in which there are two circuits at different pressures. The adjoining diagram of the machine shows the connections with the external circuits.

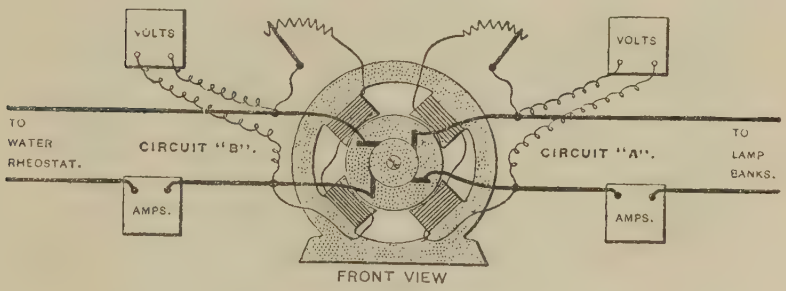
The test was made with a dynamo of 20 kilowatts capacity, and comprised the following :—

1. The effect produced upon the pressure of the circuit A (see fig.) by altering the pressure in circuit B without altering the external resistance in that circuit.

2. The effect produced upon the pressure of circuit A by keeping the current in circuit B constant, and reducing the pressure in that circuit from 110 to 0.

3. A determination of the efficiency of the dynamo when connected as a single-circuit multipolar machine at various loads up to the capacity of the machine.

4. A determination of the efficiency of the dynamo, when connected as a multi-circuit machine, circuit A only being closed and the load raised to 90 amperes.



5. The efficiency of the dynamo when connected for multi-circuit work under the conditions previously given for tests 1 and 2, and also when the current in B is kept constantly at 50 amperes.

6. The amount of power consumed in friction by the bearings and brushes.

7. The power absorbed by the dynamo in eddy currents, friction, and hysteresis losses under various conditions.

8. External characteristics under various conditions of operation.

The variation in the pressure of circuit A when the E.M.F. and current in circuit B are varied is shown in the following table in which the results are the average of three readings taken at two-minute intervals. In Table A the performance of the machine is shown when the E.M.F. and current in B are varied, the resistance being kept constant. In the case of Table B the current was kept nearly constant by varying the external resistance ; the pressure was lowered in steps in circuit B. The results show that circuit A is practically independent of circuit B, though it might be supposed that the variation of the pressure in one might affect the output of the other.

TABLE A.

(A) Amps.	(A) Volts.	(B) Amps.	(B) Volts.	Time.	Revs. per min.
48·25	96·6	51·2	111·8	2.48 p.m.	931
50	100·6	42	91·6	2.54 p.m.	945
50·7	101·5	32·7	71·6	3.00 p.m.	943
50·5	101·2	24·8	54·4	3.06 p.m.	938
50·25	100·6	13·4	29·3	3.12 p.m.	941
50	100	5	11	3.18 p.m.	943
49·75	99·6	1·5	4	3.24 p.m.	942
50·5	101	0	3	3.30 p.m.	949

TABLE B.

(A) Amps.	(A) Volts.	(B) Amps.	(B) Volts.	Time.	Revs. per min.
48·1	101	50·58	113·5	3.34 p.m.	941
48·1	101	50·5	90·5	3.58 p.m.	933
48·7	102	50	70·3	4.11 p.m.	937
48·75	102·5	48·75	47	4·26 p.m.	939
48·75	102·5	50·3	29·6	4.36 p.m.	940
49·3	103·5	51·16	10	4·58 p.m.	941
48·75	102·25	0	3	5.02 p.m.	945

W. G. R.

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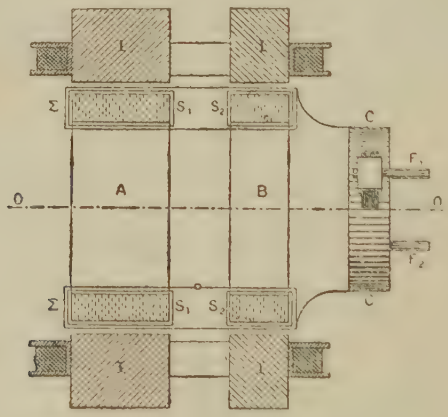
620. *Compounding Alternators for Constant Pressure.* **M. Leblanc.** (Comptes Rendus, 127. pp. 716–719, 1898.)—This



article describes an arrangement by means of which the exciting current of an alternator is made proportional to the output.

Suppose the alternator to be for three-phase currents, then in the figure two rings A and B are placed on an axis OO. The

ring A carries a first winding S_1 of the rotary machine which consists of a number of circuits at a fixed angular distance apart equal to those of the armature of the alternator. They are connected in series with the corresponding circuits of the alternator by means of rings and brushes. The ring B carries a second winding S_2 similar to that in A, but connected in parallel with the armature circuits of the alternator by means of rings and brushes. The two rings A and B are keyed on to the shaft OO in such a way that the plane passing through the axis and the middle of the ring A, makes with the plane through the axis and the middle of the ring B an angle ω, given by $\tan \omega = \frac{2\pi n L}{R}$ where n is the frequency, and L and R the self-induction and resistance respectively of each armature circuit.

A third direct current winding Σ is wound on A and B, and is connected to a collector CC. Two brushes F_1 and F_2 supported on this collector take the exciting current of the alternator. These two rings rotate between the ordinary inductors I. These inductors should be fixed in such a way that the machine, running at its normal speed, cannot excite itself when working as a direct-current machine.

The axis OO of the exciter should rotate synchronously with the alternator and in such a direction that the rotating field due to the circuits S_1, S_2 remains fixed relative to A and B. The continuous current-winding moving through this flux will develop a constant pressure between the brushes F_1 and F_2.

The exciter, thus wound, works as an ordinary converter without having any mechanical connection with the accompanying alternator. It takes from the circuits S_1 and S_2 the energy necessary to keep up its motion, and to produce the continuous current which is collected at the brushes. W. G. R.

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621. *Commutator Design.* **F. J. A. Matthews.** (Elect. Rev. 43. pp. 584–586, 1898.)—In discussing the cost of production of modern direct current dynamos, the author considers that owing to increasing wage rates and shop expenses the cost of production is more likely to have an upward rather than a downward tendency in the future. There is, however, ample room for improvement in many of the machines now on the market. It is questionable whether in cotton mills, for instance, where the hours of lighting do not exceed 500 per annum, it is not more economical for the mill owner to purchase for less money a dynamo having a lower percentage of efficiency than pay a high price for a machine with an efficiency of 94 per cent., as the saving in coal is not commensurate during such short runs with the percentage set aside for depreciation and interest. But what is of the very greatest importance is that the machine when set

to work should run with the minimum of attention and absolutely no sparking. The causes of sparking are classified as follows:—

1. Faults inherent in the dynamo design.
2. Faults due to the bad setting of the brushes.
3. Causes entirely outside the machine.
4. Faulty construction of the commutator.
5. Bad connections.
6. Commutator too small.

The article discusses the three latter causes and briefly dismisses the first three. The author points out that a commutator is a most unmechanical construction, judged from an engineering standpoint; yet, with careful designing and supervision during construction and in the hands of an attentive dynamo tender, there is no reason why this, which has always been the weak part of direct current machines, should not retrieve its character.

L. J. S.

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622. *Thickness of Transformer Plates.* **F. Bedell, R. M. Klein,** and **T. P. Thompson.** (Phys. Rev. 7. pp. 242–245, 1898.)—There is evidently a best thickness for transformer stampings since as the thickness diminishes the proportion of insulation increases as also does the induction density and consequently the hysteresis loss per c.c. of iron in the core.

The hysteresis and eddy current losses in watts are represented respectively by—

$$W_h = V\eta\, n\, B^{1.6}\, 10^{-7}$$

and

$$W_e = V\gamma\, (tn\, B)^2\, 10^{-21}$$

where V is the volume of iron in c.c., n the frequency, B the maximum induction, η a hysteresis coefficient dependent upon the quality of the iron, t the thickness of the plate in mils. including oxide or insulation, and γ is the conductivity of iron.

From these formulæ the authors draw curves for different thicknesses of plates and different frequencies and compute that the range of best thickness of transformer plates, for usual frequencies, is from 10 to 15 mils.

W. G. R.

POWER DISTRIBUTION, TRACTION, AND LIGHTING.

623. *Pressure Regulation in Three-wire Systems.* **C. del Proposto.** (Écl. Électr. 17. pp. 221–229, 1898.)—Two conditions are to be fulfilled: the maintenance of constant pressure between the outers and the equal division of the pressure between the two branches. Where the variations of load are sudden and great, ordinary methods of regulation are too slow to cope with them. The author discusses the use of two dynamos in series, compound wound to give constant pressure at the feeding point when the load is balanced, and provided with supplementary field coils in series with each other and with the middle wire, which compensate for the drop in the middle wire when balance is disturbed. The theory of the method and the mode of calculating the windings are given, and an alternative arrangement is described. The pair of machines must be designed to suit a particular three-wire feeder, and special provision must be made if the machines are to be interchangeable with others, and to run in parallel with others.

Similar methods are applied to the case of two-wire feeders with balancing machines in substations. It is shown that the ordinary system of two shunt-wound dynamos coupled together can never give true equality of pressures when the load is not balanced, since the resistance of the armatures cannot be zero. The defect is remedied by exciting the shunt winding of each machine from the terminals of the other, when exact balance will be maintained provided the magnetisation characteristics of the machines fulfil a simple condition. Two devices of Siemens and Halske are discussed, which involve the use of supplementary field coils in series with the middle wire; these are said to be inferior to the first method in efficiency. In all three methods, two separate machines coupled together are necessary, instead of a single field and double wound armature. The variations of speed of the armatures are discussed, with the aid of graphic methods; these variations are small, but very detrimental to regulation when the load varies widely and suddenly. The application of the system to five-wire networks is also briefly discussed. A. H. A.

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624. *Transmission Plant of the Fries Power Company.* (Amer. Electn. 10. pp. 447–450, 1898.)—This installation derives its power from the Yadkin river, a dam having been built across the stream giving an available head of 10 feet. The plant at present installed consists of 8 vertical turbines of 165 H.P. each, geared to a horizontal shaft, and a 750 kw. generator of the 3-phase inductor type wound to give 12,000 volts at 166 revolutions per minute, thus obviating the use of step-up transformers.

The main transmission line is carried on poles, the distance being 13½ miles. Induction motors are used when the units do not exceed 50 H.P. and synchronous motors for larger units. The power at the generating station will shortly be doubled.

M. G. W.

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625. *Electric Traction.* **C. A. Carus-Wilson.** (Soc. Arts Journ. 46. pp. 833–843, 845–854, 857–869, 873–883, 1898.)—The first of these Cantor Lectures deals with motors at rest. The "induction factor" M of a motor is expressed as follows: $M = pAN10^{-8}$ where A represents the number of conductors on the surface of the armature, N is the number of useful lines of force which enter the armature from any one pole, and p is the ratio of the number of surface conductors in series between the main terminals of the machine to the number of surface conductors lying between two adjacent neutral points: in a two-pole machine p will be unity, but in a four-pole machine it will be two or one according to the armature connections. If t represents the torque on the shaft in inch-pounds, and the armature carries a current of C amperes, then $t = 1{\cdot}41CM$. Plotting the induction factors as ordinates and the amperes as abscissæ, we obtain the "induction curve" representing the magnetic condition of the motor at rest. To obtain the characteristic from this induction curve, we have only to multiply the value of M by the number of revolutions per second. Torque is proportional to MC, and hence in a series motor it would vary as the square of the current if the iron had no reluctance. Herein lies the great advantage of series winding for railway motors. Taking the difference between the curve of total torque calculated from the induction curve and the curve of useful torque found by test, we obtain the torque lost in friction of gear and bearings, hysteresis, &c., giving us the mechanical efficiency, which for a G.E. 800 motor is found to be 84 per cent.

Lecture 2 deals with the motor in motion. If the current through the armature of a revolving shunt motor is momentarily broken, the deflection on a voltmeter across the brushes hardly changes, showing that the motor itself is inducing a tension of the same sign with respect to the voltmeter as that of the line. If n is the number of revolutions per second of the motor, the back E.M.F. or "induced tension" is nM. The induction curve can most readily be calculated from the formula $M = (E - CR)/n$, where E is the pressure on the line and C and R are the current and resistance in the armature. When the speed is uniform the current through the motor is determined solely by the retarding torque on the shaft. Obtaining n from the above equation for M, we find that the speed is made up of two parts, one depending upon E and the other upon C which in turn depends on the load. We can thus determine the behaviour of shunt and series motors with varying load.

Passing on to the consideration of the motor under acceleration (A ft. per sec. per sec.) we have $A = 32{\cdot}2\ T/W$, where T is the difference between the assisting and retarding force and W is the weight of the revolving parts. It is therefore not a fact that a heavy train takes more current to start than a light one: we can make it take whatever current we like, but the rate at which it starts up depends on the amount of current. If we have the profile of a line, the resistances to motion and the induction curve of the motors, we can predetermine with remarkable certainty the shape of the acceleration curve, which is all important on such lines as the Central London where the motors hardly ever run for any time at full speed.

The third Lecture discusses the various methods of motor control. If we vary the resistance by means of a rheostat in series with the armature of the motor we can keep the acceleration constant as long as we have any resistance in circuit to vary: after this the acceleration begins to diminish. Given the curve of acceleration from rest, we can find the distance in feet that will have been covered in a given time by drawing a vertical line through the point in the time base corresponding to the given time and finding the area included between the line, the curve, and the time base. Similarly by drawing a vertical line through a given point on the time base of the current curve, we get an area representing the watt-seconds of work done up to that time. Acceleration and current curves taken from several railways are given.

The fourth Lecture shows how to determine the best equipment that will start a train from rest and carry it through a given distance in a given time. If a train weighing W tons has to be moved through D feet in t seconds, the diameter of its wheels being d, the velocity ratio of the gear v, and the induced volts e, then $s = 0{\cdot}262\ de/Mv$. Also the acceleration (a) in ft. per sec. per sec. is $a = 0{\cdot}04\ Mv/d \times C/W$. For a given equipment and a given value of D there is a best diameter for the wheels. The use of series winding reduces the heat loss and in consequence enables the car to be carried through a given distance in a given time with considerably less energy than with motors of constant induction factor. E. H. C.-H.

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626. *Accumulator Traction.* **M. van Loenen-Martinet.** (Rly. World, 7. pp. 304–305, 1898.)—In a report presented to the Permanent International Tramways Union, the author reviews the present position of accumulator traction. At Hanover the plates are estimated to last 35,000 to 45,000 car kilometres, and at Dresden from 20,000 to 23,000 car kilometres, the latter being equivalent to from 2 to $2\frac{1}{3}$ years. There are 105 accumulator cars in regular use at Hanover and 40 in reserve. A reserve of 10 per cent. is sufficient to allow for the overhauling of batteries. After a car has run 10,000 kilometres by the accumulators, the

latter are cleaned without removing from the car, and plates replaced where necessary. This operation takes two days. A staff of twenty-five men is required to clean and repair the batteries, and the cost per annum per car is about £34 12s. 0d. At Dresden the batteries are cleaned at the end of six months, and the maintenance is guaranteed at a certain figure. The repairs are said to cost from 3·6 to 4·8 centimes per car kilometre, but this is probably too low. W. R. C.

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627. *Conduit* v. *Trolley System.* **J. Young.** (Rly. World, 7. pp. 415–418, 1898.)—This is a report to the Glasgow Tramways Committee as to whether the conduit system should be experimentally tested upon a portion of the Glasgow tramways. The author refers to the figures recently published as to the comparative costs of cable, electric, and horse traction in New York (see 1899, Abstract No. 524). The cost of operating the conduit there obtained, viz., 5·03d. per car mile, or 37·9 per cent. of the receipts, throw a very favourable light upon this system. To convert the 37 miles of double track in Glasgow to the conduit system would cost approximately about £10,000 more per mile of double track than if the trolley were employed. Assuming 122,000 car miles per annum per mile of single track, the interest and sinking fund on the extra cost amounts to about ½d. per car mile. All possible items being included, the extra cost should not exceed 1d. per car mile. Owing, however, to local conditions, such as insufficient depth of road metal over bridges and railways, the initial outlay might be higher than the above estimate ; and the author does not think the advantages of the system are sufficient to demand a trial. W. R. C.

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628. *Passenger Locomotive Truck.* (Rly. World, 7. pp. 302–303, 1898.)—A description is given of a truck built by the Brill Company for one of the French railways. It is intended for a bogie motor car, 96,000 lbs. in weight, which is to be capable of hauling a train. As accommodation has to be provided for passengers, these trucks depart in detail considerably from the ordinary electric locomotive truck. W. R. C.

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629. *Single and Double Truck Cars.* **J. J. Beggs.** (Rly. World, 7. p. 377, 1898, and Proceedings of American Street Railway Association.)—The author is in favour of double truck cars as they give rise to increased traffic, the travelling being easier than in single truck cars. Greater speed is possible, and at Milwaukee it has been found that more headway may be allowed without loss of traffic. The wear and tear is probably less than that which occurs with single truck cars. W. R. C.

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630. *Allen and Peard's Mechanical Contact System.* Elect. Rev. 43, p. 963, 1898.)—The car wheel depresses a lever which raises a contact plate above street level, but the plate is not alive until the collector on the car has raised it further. The switch gear is attached to the lid of the boxes and can be quickly replaced. The inventors claim less cost than for trolley system. E. H. C.-H.

631. *Old Rails as Sleepers.* (Street Rly. Rev. 8. pp. 792–794, 1898.)—The Rochester Railway Company, N.Y., have used old 52-lb. rails as sleepers for their new 86-lb. rails with good results. W. R. C.

632. *Track Construction.* **T. H. Gibbon.** (Elect. Engin. N.Y. 26. pp. 370–371, 1898.)—The author discusses the defects of present track construction and suggests a compound rail consisting of three longitudinal parts, breaking joint. The author claims greater rapidity in laying, greater durability, and lower maintenance, but gives no figures as to cost. W. R. C.

633. *Preservation of Sleepers.* **W. H. Glenn.** (Street Rly. Rev. 8. pp. 890–891, 1898.)—The author draws attention to the advantages of creosoting sleepers for tramways and gives figures as to cost. W. R. C.

634. *Detroit Automatic Switch.* (Street Rly. Rev. 8. p. 889, 1898.)—An account is given of an automatic switch for points on tramways. An insulated section, in circuit with the switch mechanism, is introduced on the trolley line. Normally the switch is set in one direction. But if the motorman wishes to take his car on to the branch line he continues to take power when the trolley passes along this section (20 inches in length). If he wishes to keep on the main track he cuts the car motor off while passing the section. These switches are found to work well in Detroit. W. R. C.

635. *Energy Meters on Three- and Five-Wire Systems.* **P. Bary.** (Ind. Elect. 7. pp. 449–450, 1898.)—The author discusses the use of energy meters from the consumer's point of view; and shows by analysis that where a consumer is supplied by three or five wires, unless the system is in perfect balance, the energy meter will always register a greater amount of energy than is actually supplied. A. H. A.

TELEGRAPHY AND TELEPHONY.

636. *Economy in Charging Accumulators from Primary Batteries.* **L. Brunelli.** (L'Elettricista, April, 1898; also Écl. Electr. 17. pp. 248–250, 1898.)—With n telegraph circuits (each of resistance r) n batteries are required for the signals to be of uniform intensity whether one or more circuits are operating. A single accumulator will yield this result, and even when charged by primary cells it is an economy on such cells used directly.

If R is the external res. of one of the n circuits, and r the internal res. of the battery—

$$\frac{I}{i} = 1 + (n-1)\frac{r}{R-r}$$

That is, the current in a single signal is to the current sent in one of several simultaneous signals in the above ratio, which was 3 to 2 in a certain example with one primary battery. M. O'G.

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637. *Telephone Repeater.* **K. B. Miller.** (Elect. World, 32. p. 348, 1898.)—A double-pole receiver is rigidly connected to a solid back transmitter and the whole placed in a vacuum. There is a well-defined gain in volume without loss of articulation.

M. O'G.

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638. *Dielectric for Telephone Cables.* (Electrician, 41. p. 529, 1899.)—By diminishing the solid material 25 per cent., an improvement in capacity of 15 per cent. is obtained. This diminution is secured by using a gauze called "leno" instead of paper. M. O'Gorman exactly reproduced a Post Office cable and obtained the following relative results:—

	Capacity per Mile, all Wires to Lead.			Ins. Res. Megs. per Mile.
	Max.	Min.	Mean.	
"Leno" Cable	0·0715	0·0633	0·0668	2000
Paper Cables	0·0798	0·0743	0·0773	5000
	0·0794	0·0723	0·0777	,,
	0·0737	0·0683	0·0721	,,

M. O'G.

SCIENCE ABSTRACTS.

PHYSICS AND ELECTRICAL ENGINEERING.

MAY 1899.

GENERAL PHYSICS.

639. *Homogeneous Deformation.* **L. Januszkiewicz** and **W. Voigt.** (Wied. Annalen, 67. 2. pp. 452–458, 1899.)—The authors tested the strength of rock salt in air and under a pressure of 52 atmospheres, exposing it to the same tensile strain, in order to determine a possible effect of cross pressure upon tensile strength. But they found no difference in the two cases. E. E. F.

640. *Deformations of Metals.* **M. Brillouin.** (Annal. Chim. Phys. 14. pp. 311–331, and 15. pp. 447–469, 1898.)—In the first place the author imagines a substance composed of perfectly elastic particles embedded in a network of viscous matter. He studies the way the substance would behave when subjected to forced and to free oscillations. To some extent the results agree with practice. In one case the theory differs from practice; for example, the author finds that the logarithmic decrement given by the ideal substance when subjected to torsional vibration should be largely dependent on the period, a result differing from some of Tomlinson's observations.

Partly on this account the author is led to consider a structure in which the particles possess viscosity as well as elasticity. He does not find, like Tomlinson did in certain cases, that the decrement is independent of the period. He finds, however, that the decrement is a variable which passes through a minimum value, and at this point the change in the decrement is small.

Finally a specific structure, resembling brickwork, is considered, and its behaviour under traction and compression very carefully examined, even the surface tension of the viscous matter being taken into account, when free surfaces are developed in the pores under prolonged traction. A. Gs.

641. *Deformation of Marble.* **P. Gamba.** (N. Cimento, 8. 4. pp. 273–284, 1898.)—A slab of marble supported at its extremities is subjected to both upward and downward forces at its centre. The deformations are measured optically, each end of the slab being provided with an upright mirror. A ray of light is reflected twice by one mirror, and once by the other; thus an angular movement is magnified six times. Curves are given indicating the deformations produced when the slab passes through unilateral and bilateral cycles. A. Gs.

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642. *Measurement of Twisting Strains.* **E. G. Coker.** (Phil. Mag. 46. pp. 520–528, 1898.)—This paper, read at the Bristol Meeting of the British Association, 1898, describes two arrangements of apparatus for measuring small strains in bars subjected to twist and for the determination of the Modulus of Rigidity. One form of the apparatus consists of a graduated circle mounted on a chuck-plate, having three centring-screws adjustable by hand. A ring secured to the test bar at a known distance carries an arm in which slides a tube, so that a contact-ball at its outer end can be brought into position touching the end of a screw-micrometer gauge carried on the vernier-plate of the graduated circle. When the contact pieces are touching, an electric circuit is completed through the test bar, and a galvanometer-needle is deflected. A twisting-moment being applied to the test-bar the contact pieces are separated, and the micrometer-screw must be advanced until the circuit is completed. The number of divisions through which the screw has been turned gives a measure of the angular displacement. The calibration of the instrument is described.

A clamp-bar for the purpose of setting the graduated circle accurately, with its plane perpendicular thereto and its centre corresponding with the longitudinal axis of the bar, is described. In the second form of the apparatus a reading microscope is used to observe the relative angular displacement of a radial line upon the vernier-plate. The graduated circle of this instrument is carried by a self-centring chuck of somewhat novel form, which is fully described in the paper. Illustrations of the instrument and details of calibration tests are given. A. S.

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643. *Elasticity of Muscle and of Rubber.* **A. Chauveau.** (Comptes Rendus, 127. pp. 1180–1189, 1898.)—The muscle behaves under load like a metallic rod, but its elasticity increases after each partial stretching. A muscle (forearm), sustaining 250, 500, 750, 1,000, 1,250 g. and then further weighted with 250, 500, 750 . . . g. is in each of these cases stretched by the same amount. But when five loads of 250 g. are applied successively, the partial extensions of the muscle under

each additional 250 g. decrease more and more, so that the total extension is less (about half) than that which results when the whole 1250 g. are applied at one time. The extension depends upon the ratio of additional load to weight sustained. The case is different with vulcanised rubber, whose extensions increase more rapidly than the loads. The experiments were made with rubber tubings, 0·20, 0·40, and 0·60 m. in length, with solid rubber threads, and with rubber belts, the partial loads being increased from 250 to 750 g. H. B.

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644. *Capillary Constants.* **A. Gradenwitz.** (Wied. Annalen, 67. 2. pp. 467–473, 1899.)—The author tests the validity of Quincke's method of determining capillary constants from solidified drops. It is impossible to obtain accurate values of the curvature owing to the roughness of the surface. The best method consists in projecting the drops enlarged upon a transparent screen of section paper, and measuring the height and width. Even so, errors are introduced by expansion and contraction on solidifying, or by the absorption of gases. Tin, silver, bismuth, water, and mercury were the bodies examined. E. E. F.

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645. *Surface Tensions.* **A. Pockels.** (Wied. Annalen, 67. 3. pp. 668–681, 1899.)—The authoress determines the tension of the surface separating two liquids by means of the cohesion balance. One method employed consists in the direct measurement of the surface tension by dipping an adhesion ring into the lower liquid and then lifting it up. The other method is indirect. The second liquid is allowed to expand on a contaminated water surface. This reduces the surface tension of the water until the expansion ceases. The remaining surface tension of the water is then measured with the cohesion balance. The surface tension between the two liquids is then obtained by deducting the surface tension of the upper liquid from the surface tension of equilibrium. Measurements made by the first method show a rapid reduction of the intermediate surface tension with time. Thus the surface tension water-benzol was 3·43 mg./mm. when fresh, and 3·22 after ten minutes. This recalls the behaviour of pure water on exposure to air, except that the change is more rapid. Like contaminated water, the surface tension increases on expansion and diminishes on contraction. The authoress also shows how the purity of oils may be tested. It suffices to pour drops of the two oils on to the same water surface. That which shows the colour corresponding to the greater thickness is the purer of the two. E. E. F.

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646. *Improved Barometer.* **K. R. Koch.** (Wied. Annalen, 67. 2. pp. 485–488, 1899.)—The author has introduced several improvements in his standard barometer constructed in 1895. The mercury is introduced into the vacuum by distillation. The volume of the vacuum is so large that air creeping up into it does not produce a perceptible difference of pressure. Moisture is kept down by a large quantity of phosphoric pentoxide. The vacuum can be tested at any time by a vacuum tube, which is furnished with outside electrodes to avoid occluded gases. If the vacuum is faulty, it can be restored by means of a permanently attached Sprengel pump. E. E. F.

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647. *Geissler Pumps.* **G. Guglielmo.** (Roma, R. Accad. Lincei Atti, 7. pp. 240–249, 1898.)—The author describes two forms of pump, which he considers to have advantages over the ordinary design in being more portable and less liable to injury; moreover, the intrusion of air from outside is practically impossible, even with stopcocks not very accurately fitted, and the degree of rarefaction obtained may be easily and exactly determined. Two figures are given in which the essential parts are drawn to scale. G. B. M.

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648. *Hydrodynamics.* **E. W. Brown.** (Science, 8. pp. 641–651, 1898.)—An interesting semi-popular *résumé* of recent progress towards the solution of problems in hydrodynamics, and of the outstanding difficulties. A. D.

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649. *Interpretation of a Limited Number of Results.* **E. Vallier.** (Comptes Rendus, 128. pp. 654–656, 1899.)—When a large number of measurements of the same quantity are available it is correct to take their arithmetical mean. But when the number of readings is small, a single reading, differing widely from the others, is usually omitted. This is obviously incorrect, since, if the reading is a high one, a lower mean result is obtained than if it had been a less high one. The author therefore gives the following rule: If only a limited number of readings are available, and a widely divergent value is amongst them, for which there is no intrinsic improbability, take the arithmetical mean of all the values, and add to it the quantity, $-\frac{1}{2}\frac{s_3}{s_2}$, where s_2 is the sum of the squares, and s_3 the sum of the cubes of the differences from the arithmetical mean. E. E. F.

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650. *Ancient Mirrors.* **Berthelot.** (Annal. Chim. Phys. 15. pp. 433–444, 1898.)—Classical specimens, of various provenance, are seen to have been made by blowing a thin-walled ($\frac{1}{4}$ mm.) bulb of glass and pouring melted lead into a watch-glass-shaped portion thereof, and manipulating so as to spread the metal into a lining layer about $\frac{1}{10}$ mm. thick. The glass had to be thin enough not to crack on contact with the melted lead. A. D.

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651. *Physiological Action of Alternating Currents.* **J. L. Prevost** and **F. Battelli.** (Comptes Rendus, 128. pp. 668–670, 1899.)—The authors give the results of 170 experiments made upon dogs, cats, guineapigs, rabbits, and rats, with currents of 45 periods per second, and with 5 to 4,800 volts. High-tension currents applied for a fraction of a second between the head and the feet produce grave troubles of the nervous system, including convulsions and temporary or permanent suspension of the respiration. The auricles of the heart are stopped in diastole, while the ventricular contractions proceed as before. Impending death can often be averted by artificial respiration.

Lower E.M.F.s, say 60 volts, produce tetanic convulsions, but only when applied to the head. When the contact exceeds a second, fibrillary tremblings of the ventricles set in, which in the case of the dog are fatal. In the other animals, paralysis of the heart may be obviated by a short application of a current of high tension, and by artificial respiration. There is no appreciable rise of temperature, unless the application of the current is prolonged. *Post-mortem* examinations show no intra-cerebral hemorrhage nor any other constant characteristics of death by electricity. E. E. F.

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652. *Theory of Bicycle-Steering.* **G. T. McCaw.** (Engineer, 86, p. 557, 1898.)—A mathematical investigation of the effect of rake, and distance of the centre of front wheel from the steering axis, on the steering of a bicycle. The practical results deduced from the formula are as follows: In the first place, a choice of rake is allowed, but the angle of rake having been chosen, the position of the steering axis is absolutely fixed for a given speed, the distance from point of front wheel contact with base line to the point where the steering axis cuts the ground being inversely proportional to the sine of the angle of rake, inversely proportional to the fraction of the resultant weight on the front wheel, and directly proportional to the square of the speed. In an example worked out, for a speed of $10\frac{1}{4}$ miles per hour, this distance varies from 5·33″ to 2·40″ for rake angles 15° to 35°; while the distance betweeen front wheel centre and steering axis varies from 1·53″ to 6·06″. A. S.

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653. *Absolute Velocity and the Ether.* **O. Lodge.** (Phil. Mag. 46. pp. 414–426, 1898.)—The author is of opinion that energy has all the marks of objectivity, and states a series of propositions, of which the last three are: "(6) Stresses exist solely in the Ether; (7) the Ether as a whole is at rest, and Velocities referred to it are Absolute velocities; (8) the two fundamental Forms of Energy are distinct and are possessed by different bodies, viz., Potential by ether, Kinetic by matter; hence whenever there is transference there is transformation, and whenever there is transformation there is transference." In a subsequent parenthesis it is remarked that "there is nothing here to prevent etherial energy from being ultimately hydro-dynamically kinetic, but considered from the practical material point of view etherial energy is what it has been agreed to call 'potential'; *i.e.*, it displays itself as a force to which matter can yield, rather than as a motion which something in space can resist." G. B. M.

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654. *Inertia as a Manifestation of the Ether.* **C. Barus.** (Science, 8. pp. 681–685, 1898.)—The author describes experiments, in which a fine tube contains in the centre a thread of coagulated gelatine solution, and at either end a thread of mercury. Pressure being applied to the mercury at one end, globules of mercury pass in succession through the solution towards the other end. Instead of the gelatine solution now suppose ether. Barus claims the right to make his ether solid or liquid, continuous and rigid, or discontinuous, triturated, virtually rigid, as the conditions warrant. In fact, it may be defined as a solution of the differential equations of dynamics. If there be a body placed in the continuous ether, and an impulse be applied to it setting it in motion, there will be discontinuous or triturated ether behind the body, and sheared continuous ether in front of it. Then again he supposes the triturated region, however produced, to exist without any material particles. The triturated region is a seat of energy, and Barus says that it cannot be at rest, but must be continually breaking down the continuous ether in front of it or in all directions round it. The resistance to breaking down varies *cæteris paribus* as the velocity, and as the front presented to the continuous ether, which may then represent mass. This behaviour of the region he finds to be an approach to Newton's first and second laws of motion. S. H. B.

LIGHT.

655. *Optical Measurement of Diameters.* **M. Hamy.** (Comptes Rendus, 128, pp. 583–586, 1899.)—The author applies Fizeau's method (in which the objective of a telescope is covered with a screen containing two slits, whose distance apart is adjusted until the fringes in the focal plane disappear) to the measurement of the diameters of Jupiter's satellites and the planet Vesta. He constructed a series of screens with slits various distances apart, and found which of them made the fringes disappear. The results obtained accord very fairly with the best micrometric measurements. The diameter of Vesta, 0·54″, is precisely equal to Barnard's value. E. E. F.

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656. *Quartz Plate Normal to the Axis.* **R. Dongier.** (Journ. de Physique, 7. pp. 643–648, 1898.)—This paper describes and gives the theory of a method of control in making the parallel faces of a quartz plate normal to the axis.

The method was proposed by Beaulard, who used a banded spectrum instead of the Airy spirals used in practice. The apparatus, besides that necessary for producing the banded spectrum, consists of a graduated disc to carry the quartz plate, a polariser and an analyser. Before entering the spectroscope the parallel beam of white light traverses the quartz plate (placed between the polariser and analyser crossed) normally to its faces. The banded spectrum has then minimum intensity. If the plate is now inclined to the beam by rotating the disc, the bands are displaced towards the red end; and if the plate is well cut, the same number of bands will traverse the cross wires of the spectroscope for the same inclination on both sides of the normal. If the polariser and analyser are parallel, the bands lose their sharpness when the inclination increases in any plane which is not at 45° to the plane of polarisation. J. B. H.

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657. *Kinetic Theory of Crystalline Polarisation.* **J. Beckenkamp.** (Wied. Annalen, 67. 2. pp. 474–480, 1899.)—The pyroelectric phenomena of baryta and aragonite may be mechanically explained by supposing that in consequence of the heat motions of the atoms three ether currents, normal to each other, circulate round the molecule, and that at all places where there is a change in the path of the currents the ether pressure is above or below the normal. The author applies the same theory to the study of the rotation of the plane of polarisation in tridymite, and shows that in regular crystals the rotation is independent of the orientation of the crystals, but proportional to the length of the ray. E. E. F.

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658. *Faraday Effect in Salt Solutions.* **S. Oppenheimer.** (Zeitschr. Phys. Chem. 27. pp. 447–456, 1898.)—A number of saline solutions were subjected to the action of a magnetising coil, and the rotation of the plane of polarisation of a beam traversing them was compared with the rotation produced by pure water. The following are the results:—

	Specific Rotation. (Water = 1.)		Molecular Rotation. (Water = 1.)
NaCl	1·66	...	5·38
KCl	1·32	...	5·50
NaBr	1·66	...	9·32
KBr	1·41	...	9·32
$CdCl_2$	1·14	...	11·24
CH_3 COOH	0·761	...	2·54

It will be seen that the values of the molecular rotation are the same in the two alkaline bromides, and very nearly so in the corresponding chlorides. In every case the specific rotation was found to be independent of the concentration. This is particularly surprising in the case of acetic acid, since Perkin and Schönrock found that hydrochloric acid showed a definite change of rotatory power with concentration. E. E. F.

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659. *Theory of the Zeeman Phenomenon.* **D. A. Goldhammer.** (Wied. Annalen, 67. 3. pp. 696–701, 1899.)—It is possible to explain the Zeeman effect on the basis of the older magneto-optic theories, without calling in the aid of conceptions of ionic motions. This is how the author proceeds to do so: If V_o is the velocity of light in free ether, D the dielectric constant, κ the specific resistance of a body for the period T, and V the complex velocity of light in it, the electromagnetic theory of light gives—

$$\frac{V_o^2}{V^2} = D + i\frac{2T}{\kappa} \qquad (i = \sqrt{-1})$$

On introducing the real refractive index N and the coefficient of absorption K, we obtain—

$$D = N^2 - K^2,\ 2NK = \frac{2T}{\kappa}$$

and hence—

$$2N^2 = \sqrt{D^2 + \frac{4T^2}{\kappa^2}} + D,\ 2K^2 = \sqrt{D^2 + \frac{4T^2}{\kappa^2}} - D$$

Any change in D or κ, by whatever cause produced, must therefore bring about a change in N and K. It manifests itself in a change of the number and position of the absorption lines of

the body, and, by Kirchhoff's law, of the emission spectrum also. The author studies the effect of a change of gaseous resistance produced by magnetisation, and shows that the Zeeman effect only differs from the Faraday effect by the presence of selective absorption and emission in the former. E. E. F.

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660. *Grating-Spectroscope.* **H. Olsen.** (Zeitschr. Instrumentenk. 18. pp. 280–283, 1898.)—Describes an improved form of a type of instrument supplied by C. A. Steinheil Söhne, of Munich. G. B. M.

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661. *Anomalous Dispersion of Cyanin.* **R. W. Wood.** (Phil. Mag. 46. pp. 380–386, 1898.)—By squeezing fused cyanin between two glass plates upon one of which a strip of paper is pasted, prisms of 10′ to 15′ angle with excellent optical surface may be produced. A table and diagram are given showing the values of the refractive index obtained with one of these prisms for the ranges 765–648 $\mu\mu$. and 508–395 $\mu\mu$. : the results agree well with those of Pflüger. The author has not yet succeeded in making prisms by his method thin enough to transmit yellow light, so the range 510 $\mu\mu$.–650 $\mu\mu$. is omitted. G. B. M.

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662. *Condensation Nuclei.* **C. T. R. Wilson.** (Roy. Soc. Proc. 64. pp. 127–129, 1898.)—Ultra-violet rays act in moist air or oxygen like Röntgen and uranium rays in producing condensation nuclei, under the same degree of supersaturation ; but in this case the nuclei grow. In hydrochloric acid ultra-violet rays produce few nuclei. Sunlight produces nuclei in moist air. Amalgamated zinc produces dense fogs under expansions which in the absence of the metal only result in the formation of a very few drops : clean zinc or lead a similar but much slighter effect : copper or tin inappreciable. Ultra-violet light acting on a negatively electrified zinc plate produces nuclei identical with those produced by Röntgen rays, not dust particles from the plate. Discharge from a pointed platinum wire in moist air or hydrogen produces identical nuclei if a glow be observable at the point of the wire. In all these cases the ratio of the final to the initial volume of the air required to produce such supersaturation (about fourfold) as will induce the deposition of moisture on the nuclei is 1·25. If the moist air examined under Röntgen or uranium rays be that in an electric field, the nuclei are much less numerous than in the absence of a field, and if the nuclei-forming rays are turned off before the expansion, the nuclei are found to be rapidly removed by the field ; which shows the nuclei to be charged particles or ions. The nuclei produced by ultra-violet

rays or by the presence of metals are entirely unaffected by an electric field, and are therefore not ions: those produced by ultra-violet rays falling on a negatively charged plate are themselves charged. (See also 1898, Abstract No. 1033.) A. D.

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663. *Evaporation and Condensation under Röntgen Rays.* **P. Pettinelli.** (N. Cimento, 8. 4. pp. 299–303, 1898.)—Psychometric experiments indicate that Röntgen rays slightly accelerate evaporation and condensation in air at ordinary pressures and temperatures: an effect which the author attributes to a possible increase in the convective power of the air. A. D.

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664. *Another New Radio-active Element.* **P. Curie, Mme. P. Curie** and **G. Bémont.** (Comptes Rendus, 127. pp. 1215–1217, 1898.)—In addition to the new element polonium (see 1898, Abstract No. 1224, and 1899, Abstract No. 35) an entirely different element has been found in small traces in pitch-blende residues, in company with barium and analytically behaving as such, but extremely radio-active. By fractional precipitation of the chloride of barium from solution by means of alcohol, chlorides have been obtained containing chlorides of the new element ("radium") which have 900 times the radiant activity of metallic uranium. **M. Demarçay** (*ibidem*, p. 1218) has examined the spectrum and finds a notable line at $\lambda = 3814{\cdot}8$ (Rowland scale) not otherwise identifiable. The trace must be small, for the atomic weight of the barium is only very slightly altered, though it is always altered in one direction, that of increase as compared with inactive barium. The chloride of "radium" makes a photographic negative in half a minute where uranium or thorium or their compounds would take hours; and, through aluminium, it can render a film of platinocyanide of barium permanently luminous sufficiently to make it visible in the dark without any apparent supply of energy. Uranium and thorium do not produce this latter effect, probably because their action is too feeble. A. D.

HEAT.

665. *Specific Heat.* **L. Pfaundler.** (Wied. Annalen, 67. 2. pp. 439–443, 1899.)—Dealing with the source of error in Andrews' method for determining specific heats, pointed out by Gumlich and Wiebe, the author shows how the error may be eliminated by a suitable construction of Andrews' apparatus and a rational arrangement of the experiment. E. E. F.

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666. *Ratio of Specific Heats of Gases.* **L. Boltzmann.** (Comptes Rendus, 127. pp. 1009–1014, 1898.)—The author infers from the kinetic theory of gases that (1) the molecule of a perfect gas for which $k = 1\frac{2}{3}$ behaves, so far as intermolecular collisions are concerned, like a rigid sphere; this probably holds good only for monatomic gases; (2) if $k = 1{\cdot}4$, the molecule behaves, over a considerable range of temperature, like two spheres rigidly connected; this probably holds good only for diatomic gases; (3) at high temperatures k diminishes and becomes variable even for perfect gases; this is true at ordinary temperatures for triatomic and polyatomic gases; (4) for an imperfect gas which obeys the law of Van der Waals, k is always less than for a perfect gas with a molecule of the same constitution and internal qualities. But the law of Van der Waals is only a first approximation, and our knowledge of imperfect gases not enough to enable us to draw a general conclusion. The author suggests the desirability of new determinations of k for argon, mercury vapour, chlorine, air, hydrogen, &c., over as wide ranges of temperature and pressure as possible. G. B. M.

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667. *Boiling-point Curves.* **E. F. Thayer.** (Journ. Phys. Chem. 3. pp. 36–40, 1899).—Complete boiling-point curves are determined for mixtures of several liquids. The curve for mixtures of alcohol and chloroform has a minimum corresponding (at 732·5 mm.) to a mixture containing about 7 per cent. of alcohol and boiling at 58·5°.

For alcohol and acetone the boiling-points of all mixtures lie between those of the constituents. For acetone and chloroform the curve has a maximum corresponding (at 737·1 mm.) to a mixture containing about 19 per cent. of acetone and boiling at 63·4°. A mixture of benzene and alcohol containing 33·5 per cent. of alcohol distils unchanged at 66·7° under a pressure of 737 mm. (See also Lehfeldt, Abstract No. 61, 1898.) T. E.

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668. *Boiling-point of Hydrogen under Reduced Pressure.* **J. Dewar.** (Roy. Soc. Proc. 64. pp. 227–231, 1899.)—Having previously found (Chem. Soc. J., June, 1898) that the b.p. of liquid H was $-238{\cdot}4^{\circ}$ C. (35° abs.), corresponding to a resistance of 0·129 ohm, it was calculated that if, by diminished pressure, the b.p. of hydrogen could be reduced 5° or 6° C., the resistance of the platinum wire thermometer would become *nil.* For a pressure of 25 mm., the data, b.p. 35° abs., critical temperature 52°, critical pressure 19·4 at., give a b.p. of 25·4° abs., while the molecular latent heat gives 26·1° abs., or a mean reduction of about 10°. In actual experiment great difficulties arose from (1) the conduction of heat by the wires of the thermometer, (2) the small latent heat of H, (3) the inefficiency of heat isolation and the strain on the thermometer caused by solid air freezing on it and distorting the coil of wire, (4) the liquid H evaporating before the required pressure was reached. The liquid evaporated quietly and steadily under 25 mm., without any change or loss of mobility. The original resistance of 0·131 ohm fell under diminished pressure to 0·114, remaining constant for some time, the lowest reading being 0·112. This value corresponds to $-239{\cdot}1^{\circ}$ C., or a reduction of only 1°, instead of 10°, as by theory. With a view to explain the discrepancy, the experiments are being repeated with a new thermometer of much higher initial resistance, larger quantities of liquid H, and better heat isolation. S. R.

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669. *Melting-point of Cast Iron.* **R. Moldenke.** (Indus. and Iron, 25. pp. 364–365, 1898).—The author devised a special form of the Le Chatelier pyrometer, for the purpose of making experiments on the melting-point of cast iron. The platinum wires for the thermo-couple are protected by a clay tip. Both wires are covered with asbestos to insulate them from each other, as well as to serve as a protection in case the clay tip breaks while in the molten iron. The sensitiveness of the couple, even though protected by a refractory material, is such that, plunging it cold into the melted iron, the correct reading is obtained in $1\frac{3}{4}$ minutes; while, when properly heated up to redness beforehand, this time is reduced to a few seconds. Forty-eight brands of pig-iron were experimented on; their chemical compositions and melting-points are given in tabular form. A number of cast irons and steels were also experimented on. With few exceptions the temperature at the melting-point increases as the combined carbon decreases, this being the case independent of the amount of graphitic carbon present. A. S.

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670. *Flame Temperatures.* **F. Berkenbusch.** (Wied. Annalen, 67. 3. pp. 649–667, 1899).—The author tests two new

methods indicated by Nernst for the measurement of flame temperatures. These methods are designed to eliminate the errors due to the difference of temperature produced by conduction and radiation between the flame and the thermo-element immersed in it. The first of these methods is founded upon an estimation of the rate of heating and cooling of the thermo-couple. The temperature of the couple at which the transfer of heat from the flame to the couple would be zero is found by graphic extrapolation, and that temperature is the flame temperature sought. This method breaks down, however, owing to the impossibility of accurately estimating the loss of heat by convection. In Nernst's second method, the thermo-element is electrically heated to the temperature of the flame. The heat received from the flame is zero when the heat radiated or conducted away from the element is equal to the total heat due to the current. Hence it is only necessary to determine the loss at various temperatures under circumstances similar to an immersion in the flame. This is very nearly realised by heating in a vacuum. The heating is done by means of an alternating current. The results for a number of points in the interior of a Bunsen flame are in close accord with those given by Waggener, the mean result being 1830°. This agreement is supported by a thermo-chemical calculation of the temperature of the flame, which gives 1820° as its mean temperature, after allowing for the difference between the maximum temperature of the flame and the average temperature of the gases leaving it. E. E. F.

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671. *Thermal Radiation.* **K. Ångström.** (Wied. Annalen, 67. 3. pp. 633–648, 1899.)—The author describes a new instrument for the measurement of thermal radiation, which he calls the electric compensation pyrheliometer. It resembles in some ways the author's apparatus described in 1893, and that described by Kurlbaum in 1894. The instrument is based upon the following principle: Of two thin metallic strips, similar in every respect, one is exposed to the radiation to be measured, while the other is heated to a corresponding amount by means of an electric current. When equilibrium is attained, the energy radiated by each of the strips is equal to the energy supplied by the current and the source respectively. If q is the radiation per sq. cm. per second in gramme-calories, b the width, a the absorptivity of the strip, r its resistance per unit length, and i the strength of the compensating current, then

$$b\,a\,q = \frac{ri^2}{4\cdot 18}$$

The arrangement adopted eliminates almost all sources of error. The author gives full particulars of construction and use, and quotes a series of measurements of solar radiation made on Teneriffe, and of the radiation of a Hefner lamp. E. E. F.

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672. *Thermal Conductivity of Rocks.* **F. Morano.** (Roma, R. Accad. Lincei Atti, 7. 2. pp. 61–68, 83–89, 1898).—The samples experimented on were circular discs from rocks in the Roman Campagna, and the author first gives a mathematical discussion, involving Bessel functions, which does not admit of analysis. This is followed by accounts of the determination of the specific heats, densities, dimensions, and conductivities of the discs. Finally, tables are given to show the diurnal and annual variation of temperature at the surface and at different depths.

G. B. M.

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673. *Diathermancy of Ebonite.* **E. Bianchi.** (N. Cimento, 8. 9. pp. 285–295, 1898).—The diathermancy is 8·72 per cent. when the source of heat is a Leslie's cube at 100°, to 11·11 when it is melted lead at 320°, with intermediate values and with higher values at increasing temperatures, up to 45 per cent. for radiations coming from platinum wire at its maximum luminosity and passed through 4 mm. of alum (diathermancy 9·5). The thickness of ebonite employed was 0·5 mm. When the whole radiation from the incandescent platinum wire impinged on the ebonite, the diathermancy was only 26·2 per cent. Ebonite is thus somewhat diathermanous for sources at 100° (Becquerel *contrà*, Journ. de Phys. 6, series 3, p. 525, 1897); and it is more diathermanous to the more refrangible heat-rays. A. D.

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674. *Saturated Vapours.* **E. H. Amagat.** (Comptes Rendus, 128. pp. 649–653, 1899.)—The author points out that his form of the function, $f(p, v, t)=0$, very nearly agrees with the observed values for saturated vapours even near the critical temperature. Between the points there is a divergence which is possibly accounted for by the great difficulty of experimental determinations in that region. E. E. F.

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675. *Thermodynamics.* **K. Wesendonck.** (Wied. Annalen, 67. 2. pp. 444–451, 1899.)—When the working body receives its heat by radiation, it is only the temperatures of the surface and volume elements receiving heat from outside which should enter into discussion. E. E. F.

ELECTRICITY.

676. *Report on the State of the Mathematical Theory of Electricity and Magnetism.* **A. G. Webster.** (Science, 8. pp. 803–810, 1898.)—This is a historical sketch of the theory commencing in 1848, at which date Coulomb had already demonstrated the law of the inverse square, thus admitting the potential theory of Laplace, Poisson, and Green. The laws of current induction were subsequently established experimentally by Oersted and Faraday, and expressed analytically by Neumann. The next epoch is marked by Maxwell's work, and mention is made of other writers who, following in his steps, helped to complete or elucidate the theory. Maxwell's field equations are given, and finally the work of Hertz and Heaviside, and the theory as now existing is given in the form of a system of field equations to be compared with those of Maxwell. S. H. B.

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677. *Dirichlet's Principle.* **W. Stekloff.** (Comptes Rendus, 128. pp. 588–591, 1899.)—The author shows how problems of electrostatic distribution can be solved without the aid of Dirichlet's principle and without the introduction of doubtful premises, by a combination of the methods of Neumann, Poincaré, and Liapounoff. E. E. F.

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678. *Alternating Electric Arc.* **A. Blondel.** (Comptes Rendus, 127. pp. 1016–1021, 1898.)—Contains a series of figures showing the variation, with the time, of the potential difference between the points of the carbons and the corresponding current intensity. The nature of the curves obtained depends upon the kind of carbons used and the inductive or non-inductive character of the circuit. The "normal arc" is obtained by using pure homogeneous carbons, as the presence of a core or of mineral salts tends to mask the characteristic features of the phenomenon.
G. B. M.

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679. *Electric Arc.* **F. Eichberg** and **L. Kallir.** (Écl. Électr. 17. pp. 560–566, 1898.)—The electric-arc when excited by alternating currents between electrodes of different metals shows a steady deflection on a tangent galvanometer placed in circuit with it, indicating the presence of a continuous current. This paper contains an experimental investigation of this phenomenon.

One electrode is of carbon and the other of iron. The quantities measured are: 1. The average current in the circuit, by means of a thermal ammeter. 2. The average difference of

potential between the extremities of the arc, by a thermal voltmeter. 3. The apparent continuous current, by a tangent galvanometer in the circuit. 4. The apparent constant difference of potential between the electrodes, by a torsion galvanometer. 5. The instantaneous differences of potential between the electrodes at sixteen different phases of the current, by means of a commutator mounted on the shaft of the alternator, a condenser, and a ballistic galvanometer. 6. The current in the circuit simultaneous with the differences of potential measured in 5, by similarly measuring the instantaneous difference of potential between the ends of a resistance in series with the arc.

The curves obtained from 5 and 6 are not equally above and below the axis of abscissæ, and when integrated they give results in conformity with the readings on the ordinary galvanometers, confirming the presence of an excess of current in the direction from the metal through the arc to the carbon.

It is necessary to conclude that the formation of the arc in the direction carbon-iron meets with a great resistance, the nature of which is unknown. This resistance causes the current during that half-period to be almost zero, and the difference of potential between the electrodes to become almost equal to the E.M.F. of the alternator. In the other half-period the current passes without great resistance from iron to carbon, a continuous arc is obtained, and the difference of potential remains sensibly constant between 30 and 40 volts.

The behaviour of two such arcs in parallel, but with the electrodes in opposite directions in the two arcs, is also considered. In this case the curves obtained are symmetrical with respect to the axis.

Two carbons of different nature act to some extent like a metal and a carbon. J. B. H.

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680. *Metal-Carbon Arcs.* **A. Blondel.** (Comptes Rendus, 128. pp. 727–731, 1899.)—All metals employed as electrodes in the presence of another electrode of carbon give rise to the same phenomena, and only present quantitative differences. In every case, two distinct phenomena appear in an alternating circuit thus constituted. They may be called the short arc and the long arc respectively. The former is only about 1 mm. long, and shows a certain diasymmetry between successive alternations, which is greater in the case of zinc and iron than in the case of copper and aluminium. On lengthening the arc, it begins to hiss, and the curves assume a different character. The long arc is characterised by the suppressions of the alternations on one side, since the current does not flow in the sense carbon-metal. The long arc is very unstable. In an inductive circuit the establishment of the long arc is accompanied by a sudden increase of mean intensity as indicated by the thermal ammeter. In the case of copper, the rise is from 9 to 20 amperes. This

is due to the fact that the metal-carbon currents are prolonged, and the area of curve of the squares of intensities is greater than the area of the two ordinary alternations. E. E. F.

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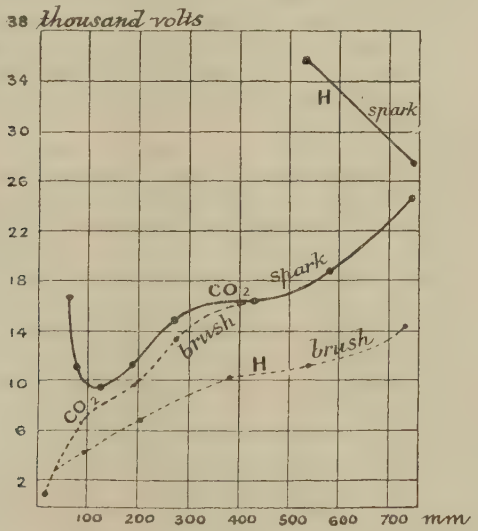
681. *Induction-Coil Discharges.* **A. Oberbeck.** (Wied. Annalen, 67. 3. pp. 592–607, 1899.)—The author adds to his former determinations of discharge potentials between spheres, points, and plates. He specially investigates the difference between spark discharges and brush discharges. He fixes two small brass spheres at a constant distance of 6 cm. apart, that being the minimum at which the two forms of discharge can be separately observed in the open air. On reducing the pressure between the spheres, the character of both discharges changes,



but the author calls the spark discharge that which is attached to both electrodes. The results are shown in the annexed diagram for hydrogen and carbonic acid. Although the curves are so widely separated in the two cases, the author believes that they are essentially of the same character, and that on proceeding further to the right the two hydrogen curves would join as they do in the case of CO_2. This is confirmed by the fact that air shows curves intermediate in character. E. E. F.

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682. *Discharge Phenomena.* **N. Tesla.** (West. Electn. 23. p. 301, 1898.)—In the *New York Sun* for November 19,

1898, Tesla described his views on the possibilities of high-frequency and high-potential phenomena. This is a reprint of his article. It is for the most part conjecture. R. A.

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683. *Vacuum Tubes with Magnetised Electrodes.* **C. E. S. Phillips.** (Roy. Soc. Proc. 64. pp. 172–176, 1898.)—The vacuum tube is a soda-glass bulb, provided with pointed soft iron electrodes, which lie between the poles of a large electro-magnet and are insulated from the poles by thin sheets of glass. The bulb can be put into connection with a Sprengel air-pump, and no precautions are taken to exclude mercury vapour from the bulb. The pressure having been reduced until kathode rays begin to appear, the electrodes are then magnetised; this causes the fluorescence on the walls of the bulb due to the kathode rays to twist slightly and to move forward. On reversing the magnetic polarity of the electrodes the direction of twist changes, but the forward motion persists; the direction of rotation is consistent with the view that kathode rays are negatively charged particles streaming from the kathode.

With lower pressures, the bulb having been strongly stimulated with unmagnetised electrodes and the stimulation then stopped, on magnetising the electrodes a luminous ring appears between them in a plane at right angles to the lines of force. The ring is seen most clearly with the highest exhaustions which permit stimulation of the bulb, and it forms equally well whether the electrodes are insulated, joined together, or put to earth, provided they are oppositely magnetised. Sometimes a second ring forms concentrically with the first one and outside it. The inner and more luminous ring forms as a bright stream from between the electrodes, which acquires a rapid rotation round the magnetic axis and fades away as its circle of rotation widens.

The author describes an experiment with external magnetised electrodes and a suitably shaped bulb. After subjecting the enclosed gas to an oscillatory discharge and then magnetising the electrodes, a flash of white light is observed in the tube, and irregular green splashes momentarily appear on the glass.

J. L. H.

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684. *Energy Consumed in Vacuum Tubes.* **H. Ebert.** (Wied. Annalen, 67. 3. pp. 608–629, 1899.)—In estimating the energy consumed by vacuum tubes fed with alternating currents, direct-current measurements are not available, owing to the phase difference introduced by the capacity of the discharge tubes. The author therefore made some direct measurements with currents of high frequency (22,000 alternations per minute) transformed up to 3,000 volts. The form of the current curve, as tested by a Braun kathode ray tube, was very nearly sinusoidal. The instru-

ments employed in the low-pressure circuit included a Cardew voltmeter, an alternate-current ammeter by Hartmann and Braun, and a Weston wattmeter. In the high-pressure circuit, a plate voltmeter and a hot-wire ammeter were employed. The energy consumed by the tube was determined from the watts consumed in the primary circuit, after deducting the heat developed in the primary, the hysteresis loss (about one watt), the loss due to capacity, and the heat developed in the secondary coil, when the tube becomes luminous. The consumption obtained gave a clue to the phase difference in the secondary circuit due to the influence of the tube. The following table shows some results obtained for nitrogen :—

Volts in primary circuit ...	30	29	30	30
Amperes in ditto	1·1	1·2	1·2	1·1
Watts in ditto	17·8	15·3 [1]	16·3	26·4
Phase difference	57°	64°	63°	37°
Heat consumed in primary coil, watts.....	1·4	1·6	1·6	1·4
Energy transformed.....	15·4	12·7	13·7	24·0
Volts in secondary circuit	1023	776 [1]	863	2100
Amperes in ditto	0·0116	0·0136 [2]	0·0136	0·0116
$E = V_{eff} \times i_{eff}$	11·9	10·6 [1]	11·7	24·4
Heat consumed in secondary coil	1·8	2·5	2·5	1·8
Watts consumed by discharge	11·1	7·7 [1]	8·7	19·7
Phase difference	21°	43° [2]	42°	36°
Pressure in mm. Hg	2·92	0·82	0·45	0·10

It will be seen that the energy consumed closely follows the product E*i*. It decreases with the pressure at first, and reaches a minimum at a certain point where E shows a decided minimum, and *i* a less decided maximum. The energy, as indicated both by the above measurements and by simultaneous calorimetric observations, attains a minimum at a certain low pressure, which in nitrogen is 0·82 mm. Measurements carried down to very much smaller pressures show that, so far as luminous effects are concerned, they may be produced at a very small expense of energy indeed. The reversal in the consumption of energy occurs in the same tube at very different pressures, according to the gas contained in it. In one form of tube the reversal pressures were found to be the following: Hydrogen 1·26 mm., nitrogen 0·65, CO 0·65, air 0·60, CO_2 0·47. These pressures are inversely proportional to the mean free paths of the molecules at atmospheric pressure. Put in another form, it may be said that, for a given valency, the reversal takes place at higher pressure the larger the sphere of influence of the luminescent molecules; or,

[1] Minimum. [2] Maximum.

if the molecular diameters are the same, the reversal pressure is the higher, the smaller the number of ionic charges disengaged by a complete dissociation of the molecule. The gases with smaller free paths have a greater "dielectric strength" than those with large free paths. In other words, the dielectric strength of a gas increases with the valency of its molecules and the smallness of its sphere of influence. All the results obtained go to support the view according to which the luminous phenomena in vacuum tubes are due to dissociations brought about by the kathode rays impinging upon the gaseous molecules. The greater the valency of the molecule, the greater is the amount of energy required for its dissociation. E. E. F.

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685. *Duration of Kathode Phenomena.* **E. Wiedemann.** (Wied. Annalen, 67. 3. pp. 714–716, 1899.)—If a discharge tube, with or without electrodes, is brought into a slightly damped high-frequency field, pure kathode phenomena are seen at both ends, without any superposition of positive effects. Hence it has been concluded that the negative phenomena persist from one half-oscillation to the next (*i.e.*, for about 10^{-6} sec.), and so hinder the development of the positive effects. It remains to be decided whether the great fall of potential at the kathode which produces the deflection of the kathode rays also persists for some time. The author's experiments gave a negative answer to this question. He cemented a glass tube into a glass bulb, so that its closed end was in the centre of the bulb. The two knobs of a spark-gap, forming the terminals of a Lecher wire system, were pressed against the bulb at points not diametrically opposed. Each of them formed a kathode during a part of the oscillation, and produced a shadow of the tube, and a wire contained in it, on the opposite wall of the bulb. On joining one of the knobs with the wire, the rays proceeding from the other knob were deflected, and the corresponding shadow was broadened, owing to the slope of potential round the wire. This slope of potential disappeared during the next semi-oscillation, as was shown by the other shadow remaining sharp. E. F. F.

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686. *Deflections of Kathode Rays.* **D. F. Tollenaar.** (Wied. Annalen, 66. 1. pp. 83–87, 1898.)—The fact observed by Wiedemann (Wied. Annalen, 63. p. 248, 1897) that when the kathode consists of a strip of metal bent so as to form two portions at right angles to one another, a fluorescent screen placed in the angle shows two marginal regions of darkness and a mesial region of brightness bounded by a double caustic whose apex is at the angle, is explained thus: Each limb repels and thus deflects the rays from the other limb, the nearer rays most powerfully. The nearer rays thus cross the farther ones.

Similarly for the other limb of the kathode. The congeries of crossings accounts for the caustic observed. The reason of the repulsion is the negatively charged kathode particles crossing an electric field; and the potential gradient in such field is altered by changes in the amount of vacuum, so as to affect the amount of deflection. A. D.

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687. *Reflection of Kathode Rays.* **A. A. C. Swinton.** (Roy. Soc. Proc. 64. pp. 377–395, 1899).—The author finds that the rays which in a focus tube proceed from the front surface of the anti-kathode and cause the green fluorescence of the glass, have exactly the same properties as kathode rays, and are, in fact, reflected kathode rays. The mechanical force they exert on mill wheels is, however, inappreciable, and the inverse rotation of such wheels when outside the kathode stream (see 1899, Abstract No. 82) is not due to them, but to some other more potent cause. The reflection of kathode rays is largely diffuse; but with a concave reflector of polished platinum a certain proportion of the rays are reflected in true specular fashion. Some further rays of an unexplained description are given off normally to the surface of the reflector. Experiments with a tube fitted with a movable platinum reflector, and also with a Faraday cylinder, capable of rotation round the reflector, connected to an electrometer, show that the field of reflected kathode rays is not uniform, but increases on both sides to a maximum which, for all angles of incidence, always occurs at the point that makes the angle of reflection equal to that of incidence. As the incidence is made more slanting, the charge carried by the reflected rays increases, while the charge imparted to the reflector and the amount of Röntgen rays produced decreases. This supports the view that the Röntgen rays are actually due to the charges carried by the kathode ray particles being imparted to the anti-kathode reflector.

AUTHOR.

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688. *Slow Electric Oscillations.* **W. König.** (Wied. Annalen 67. 3. pp. 535–562, 1899.)—The author describes several new methods for the study of electric oscillations of periods approaching to those of sound waves. They are mostly based upon the principle of Lichtenberg's figures. When a resin plate is made to rotate instead of being stationary, and a spark discharge is led through it, a series of successive red and yellow figures is obtained on sprinkling it with sulphur and minium. Better defined figures are obtained when the surface is a metallic plate painted with asphalt varnish, and the conductor has a point made of a bad conductor, such as a piece of straw. A broken red-and-yellow line is thus obtained. This may be utilised for the measurement of the spark period by attaching the straw to the prong of a

tuning-fork, through which the discharge is led. Thus a wavy line is obtained, in which every oscillation is represented by a yellow or red section, and the number of waves in each section gives a direct measure of the period. The method thus becomes very accurate and valuable, and is applicable down to 20 volts, the errors not exceeding 1 per cent. The author has applied it to verify the laws governing the period of induction-coil discharges. E. E. F.

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689. *Electric Wire-Waves.* **W. D. Coolidge.** (Wied. Annalen, 67. 3. pp. 578–591, 1899).—A method is described of making the waves in a Blondlot wire system visible by the light effects from the wires, without enclosing the latter in long vacuum tubes, as proposed by Arons. To produce very strong oscillations, the secondary ring is placed just under the primary ring, being only separated by a mica plate, and the whole is immersed in petroleum. The parallel wires are 10 to 20 mm. apart, and their diameter is only 0·1 mm. The best source is an induction coil used with a Tesla transformer. The luminous wires are photographed, and the negatives reproduced show the successive nodes and ventral segments very well, "overtones" being clearly indicated in many cases. E. E. F.

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690. *Multiple Resonance of Electric Oscillations.* **L. Décombe.** (Annal. Chim. Phys. 15. pp. 156–202, 1898.)—This paper discusses the question as to whether a Hertzian oscillator emits electric waves forming a continuous spectrum (comparable to white light) or waves of only one frequency (analogous to monochromatic light). After reviewing the work done and hypotheses proposed by Sarasin and de la Rive, Garbasso and Aschkinass, and Zehnder in favour of multiple resonance, and the experiments of Wartz, Jones, Rubens, Bjerknes, and Perot, which support the single frequency view, the author gives details of his own arrangement to test the question by the revolving mirror method. He thus arrives at the conclusion that the apparatus emits a unique oscillation of well-defined period. The *apparent* multiple resonance observed by Sarasin and de la Rive is felt to be explainable only on the theory proposed by Poincaré in 1891 as to the rapid damping in the primary oscillator and comparatively slow damping in the resonator. (See also Phys. Soc. Abstracts No. 266, 1895.) E. H. B.

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691. *Modification of Hertz Resonator.* **A. Turpain.** (Écl. Électr. 17. pp. 73–78, 1898.)—A circular resonator containing a gap (in addition to the ordinary micrometric gap or spark-gap) works as well as a complete resonator. The two ends of the conductor (having the gap between them) are connected up with

a battery and telephone; whenever sparks cross the micrometer gap the circuit becomes closed and the telephone disc vibrates. Listening to the telephone is less fatiguing than watching the spark-gap. That the introduction of an auxiliary current does not alter the conditions may be shown by suppressing the battery. The Hertzian oscillation then actuates the telephone and the note heard is of the same pitch as when the battery is in, but is less intense. The author also states that the introduction of the telephone into the resonator circuit does not alter the results obtained. These are as follows :—

I. Influence of direction of sparks in micrometer :—Two resonators, identical excepting that in one the sparks are normal to the circumference of the resonator in its plane, whereas in the other they are tangential, give the same results. The action appears to be independent of the direction of the spark, excepting that the sparking distance is greater in the case of the normal micrometer.

II. Influence of a gap and its position :—The gap varies from 2 to 11 hundredths of the total length of the resonator; as explained above, this gap was in addition to the spark-gap as contained in an ordinary resonator. When the gap is in a symmetrical position the azimuths of extinction are as in an ordinary resonator. When the gap is asymmetric the azimuth of extinction or of minimum effect is such that the azimuth of extinction of an ordinary resonator would pass through the middle of the gap. In a gap-resonator the gap plays the *rôle* of the micrometer in the ordinary resonator.

III. Influence of the gap on the wave-length of a resonator :—The difference between the half-wave-length of an ordinary resonator and the half-wave-length of a gap-resonator of the same radius is equal to the length of the gap ($\lambda - \lambda_g = 2_g$). (See also 1898, Abstract No. 512.) D. E. J.

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692. *Coherers.* **T. Tommasina.** (Comptes Rendus, 127. pp. 1014–1016, 1898.)—A ball of nickeled brass 1 cm. in diameter is hung by a fine metallic wire above the centre of a horizontal copper disc 4 cm. in diameter; a pinch of nickel filings is placed on the disc, and the bob of the pendulum arranged so as just to graze them. This forms an elementary coherer which is put in circuit with a condenser, a resistance, and a very sensitive relay which opens and closes another circuit containing a resistance box, two condensers, and a small incandescent lamp. At each spark of an oscillator at the other end of the room, the lamp glows: the slightest movement of the pendulum extinguishes it. When the disc is lowered slightly there is formed between it and the bob a single thin chain of glowing filings, along which the current continues to pass; with care a chain 2 cm. long can be

obtained. On trying different metals and alloys, it is found that the effect is inversely proportional to the oxidisability of the substance. G. B. M.

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693. *Coherers of Gold and Platinum.* **E. Branly.** (Comptes Rendus, 127. pp. 1206–1207, 1898.)—The author attributes the failure which some experimenters have had with these metals to want of sufficient care in establishing the necessary slight initial contact. He confines the filings in a tube between two plates, one of which has a screw adjustment with which the slight contact is established. The following example of the sensitiveness of a coherer with gold filings is given :—

The coherer is entirely enclosed with its relay and bell circuit in a metal case, the only opening in which is a vertical slit 20 cm. × 1 mm. A Ruhmkorff coil, 25 mm. spark with 4 volts, is placed at 20 m. distance, each terminal being connected to a horizontal brass cylinder 45 mm. diam. and 15 cm. long. The two cylinders have the same axis and terminate in spheres whose surfaces are placed 1 mm. distant. The 1 mm. spark between these balls at once makes the coherer conduct, and a slight shock re-establishes the resistance. J. B. H.

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694. *Measuring High Electric Pressures.* **W. Peukert.** (Écl. Électr. 17. pp. 332–333, 1898; Elektr. Zeitschr. 19. p. 657, 1898.) —For measuring high alternating potential differences, the author connects a number of condensers of equal capacity in series across the terminals whose potential difference is to be measured, and then measures the potential difference across the terminals of one of them. The required value is obtained by multiplying the observed value by the number of condensers in series. In an example, the apparatus consisted of 10 mica condensers, as equal as possible, arranged in a box. The surface was 135 sq. cms. They were separated by plates of paraffined wood connected together by screws. The small differences between the several condensers were exactly compensated for by varying the pressure of the wood plates. The capacity of each condenser is 0·00607 microfarad. Terminals are provided to enable any desired number of condensers to be used in series or in parallel. Other methods of proportionately reducing the potential difference to be measured, by transformers and by resistances without self-induction, are also discussed. C. K. F.

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695. *Measurement of Current Leakage.* **M. Kallmann.** (Electrician, 42. pp. 303–305, 1898; also Elektrotechnische Zeitschrift, Oct. 13 and 20, 1898.)—This method of measuring current leakage is based on the fact that if two ammeters be put

into a main or lead the difference between their readings indicates the leakage current between them. The method is carried out in practice by inserting two equal resistances at the two points between which the leakage is to be measured and connecting the ends of one resistance to one coil of a differential galvanometer, the ends of the other resistance being connected to the other coil. The deflection in the galvanometer will then be a measure of the leakage between the two points. Instead of a differential galvanometer, four equal resistances (in addition to the two before mentioned) and an ordinary galvanometer may be employed, the arrangement being similar to that in Kelvin's double bridge. The author treats of the application of this method: (*a*) to measure the leakage in a single feeder; (*b*) to indicate the currents returning through earth from the rails of an electric railway; (*c*) to show the whole leakage current from a two-wire system; (*d*) ditto from a three-wire system; (*e*) to measure the leakage currents from transmission lines to sub-stations.

E. C. R.

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696. *Measurement of Inductance.* **S. T. Moreland.** (Amer. Assoc. Proc. 47. pp. 121–122, 1898.)—Two coils are placed at right angles, and in the space inside them is suspended a hollow copper cylinder used with a mirror, lamp, and scale. If each coil is placed in one branch of a divided circuit carrying an alternating current, a rotary field will in general be produced, and the suspended cylinder will turn until the torque of the suspension equals the torque due to the rotary field. When, however, the time constants of the two branches are equal, the currents will be in phase and no rotary field will be produced, hence the cylinder will not be deflected. If the resistances of the two branches is known and also the inductance of one of them, the inductance of the other can be calculated from the formula $L_2 = L_1 \, r_2/r_1$. L_1 and L_2 being the inductances in series with the coils, plus the inductances of the respective coils themselves, which must be known, and r_1 and r_2 the resistances of the corresponding branches. A balance is best obtained by the adjustment of the resistances.

E. C. R.

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697. *Bridge Method of Comparing Low Resistances.* **H. L. Callendar.** (Electrician, 41. p. 354, 1898.)—The author criticises the use of 10,000 ohm coils instead of a slide wire. The bridge is preferable to potentiometer in that the testing current may be smaller and need not be kept constant. He also criticises Kelvin's double bridge, of which the connections are complicated and liable to thermoelectric troubles from being asymetric. An instance is given of a calibration in a power house of two 10,000 ampere shunts.

M. O'G.

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698. *Polarisation under Pressure.* **A. Chassy.** (Comptes Rendus, 127. pp. 1203–1205, 1898.)—Cailletet and Collardeau have shown that an electrolytic cell (having electrodes of spongy platinum) in which a current has been passing, has its capacity of polarisation enormously increased by external pressure. The author of this paper has investigated whether the initial capacity of polarisation is also increased by the pressure; that is to say, whether the charge produced by a very small E.M.F. increases with the pressure.

Polished plates of various metals and also spongy platinum were used as electrodes. Water acidulated to different degrees and saline solutions formed the electrolytes. Pressures up to 2,000 atmospheres were used. In every case the initial capacity of polarisation was found to be practically independent of the pressure, the variations obtained being all such as could be accounted for by other causes quite independent of the pressure.

J. B. H.

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699. *Polarisation under Pressure.* **R. Federico.** (N. Cimento, 8. 4. pp. 409–419, 1898.)—Similar results to those obtained with sulphuric acid (see 1899, Abstract No. 466); but with a 10 per cent. solution of nitric acid the maximum E.M.F. of polarisation rises 0·035 volt under 900 atmospheres, and with a 10 per cent. solution of hydrochloric acid 0·038 volt under 995 atmospheres, as against a rise of 0·113 volt with an 8 per cent. solution of sulphuric acid under 900 atmospheres pressure. The variations of the maximum E.M.F. of polarisation with the pressure are more rapid at lower pressures than at high, in nitric acid as in sulphuric acid solutions, but less markedly so; in hydrochloric acid solutions these variations are practically constant at all pressures.

A. D.

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700. *Polarisation.* **W. A. Anthony.** (Amer. Assoc. Proc. 47. pp. 138–140, 1898.)—The author investigated the polarisation of simple cells in which copper, carbon, or platinum was opposed to zinc in sulphuric acid. The cells were closed through resistances, and the recovery observed when hydrogen, nitrogen, or oxygen was passed through the electrolyte. The author arrives at the conclusion that the high initial E.M.F. of a cell is due to dissolved oxygen, so that the negative plate is really an oxygen plate. The polarisation is not due to hydrogen on the plate but to exhaustion of oxygen in the electrolyte. Contrary to the opinion of Le Blanc, the author holds that platinum is not an inert metal.

W. R. C.

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701. *Thermoelectric and Galvanic Action.* **C. J. Reed.** (Frank. Instit. Journ. 146. pp. 424–448, 1898.)—A comparison

of thermoelectric and galvanic action. The author uses the term thermoelectric to include any process in which the electrical energy is derived entirely from external heat. Some examples are given of cells which might appear to be galvanic but are really thermoelectric. Among these is included the Jacques cell. **A. E. Kenelly** pointed out in the discussion that efficiency forms a criterion by which galvanic action may be judged, and was of the opinion that a cell depending upon heat for its energy, like the Jacques cell, was not necessarily thermoelectric. Experimental evidence was required. **J. W. Richards** expressed the opinion that ordinary thermochemical data do not apply at the temperature of the Jacques cell; if such were available it would be recognised that the cell is purely chemical. W. R. C.

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702. *Electrothermal Relations.* **F. Kohlrausch.** (Wied. Annalen, 67. 3. pp. 630–632, 1899.)—The author refers to Riecke's discussion of the relations between thermal and electrical conductivity (see 1899, Abstract No. 299), and maintains that his own way of presenting the same relations does not involve any complexity. E. E. F.

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703. *Galvanometers.* **W. E. Ayrton** and **T. Mather.** (Phil. Mag. 46. pp. 349–379, 1898.)—This third paper comprises three sections: A contains two lists of sensitive galvanometer records, reduced to the standard conditions of 10 seconds period, scale distance = 1,000 scale divisions, resistance of instrument 1 ohm. The most sensitive instruments, according to the authors' criteria, are two Paschen galvanometers, and one of the Nichols type. Table IV. gives results for oscillographs, and V. VI. relate to d'Arsonval galvanometers. Section B discusses the limiting sensitiveness of Thomson galvanometers; C the comparative merits of long and short period instruments for zero methods. The authors conclude that, when practicable, the rule for rapid working is "adjust the control so that the sensitiveness is, say, two or three times as great as is absolutely necessary for the desired accuracy." G. B. M.

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704. *Sensitiveness of Movable-Coil Galvanometers.* **C. Féry.** (Comptes Rendus, 128. pp. 663–666, 1899.)—Having occasion to measure very small currents by means of a Depretz-d'Arsonval galvanometer, the author determined the ratio $\frac{r'}{r}$ of the resistances of the torsion wire and the coil which produces maximum sensitiveness in the galvanometer. As usually constructed, the resistances referred to are $r' = 0{\cdot}5$ ohms and $r = 200$ ohms. If $r + r'$ is to remain the same, the maximum deflection is obtained

when $r' = 2r$. Hence we must have $r' = 132$ ohms and $r = 66$ ohms. This increases the sensitiveness 153 times. But it must not be thought that a simple application of the formula leads direct to such an easy augmentation of the sensitiveness. Several disturbing causes intervene, the most important of which is the magnetism of the copper of the coil. This can be eliminated either by employing a perfectly uniform field or by making the permeability of the moving coil equal to unity by furnishing it with diamagnetic bodies. E. E. F.

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705. *General Electric Company's (U.S.A.) Wattmeter for Triphase Currents.* **J. W. Blackstone.** (Écl. Électr. 17. pp. 483–484, 1898.)—In this wattmeter an aluminium disc is arranged to rotate between two pairs of pole-pieces arranged diametrically opposite each other. The cores on which these pole-pieces are formed are wound with shunt coils placed respectively across conductors 1 and 2, and 2 and 3, for example, the inductance of each shunt being increased by arranging in series therewith an inductive coil wound on a core forming part of a closed magnetic circuit; the currents in the shunt coils are thus retarded by 90°. Series coils in conductors 1 and 3 are arranged in pairs by the side of each of the shunt coils, the two systems being arranged sufficiently far apart to prevent them from interfering with each other. Between the two systems are arranged two diametrically opposite brake magnets. This meter is independent of temperature variations and gave very good results when tested. C. K. F.

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706. *Tudor's Electromagnetic Contact Breaker.* (Écl. Électr. 17. pp. 447–448, 1898.)—A closed glass tube of special form contains mercury which in one position of the tube makes electric contact between two platinum electrodes sealed through the tube. The tube is mounted on the armature of an electromagnet in such a manner that when the armature is attracted the mercury flows to another part of the tube and breaks the contact. The tube is exhausted or contains a gas which does not act on mercury, and is shaped so that the spark takes place between two surfaces of mercury. J. B. H.

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707. *Unpolarisable Electrodes.* **E. Warburg.** (Wied. Annalen, 67. 3. pp. 493–499, 1899.)—Starting from the equation—

$$p = \frac{a}{C\,m} \sin\left[mt - \left(\frac{\pi}{2} - \psi\right)\right]$$

giving the polarisation p in terms of the polarisation capacity C, for alternating currents, the author calculates the polarisation

capacities of certain "unpolarisable" electrodes such as mercury in sulphuric acid saturated with mercuric sulphate, or silver in silver nitrate solution. In the latter case, if the second electrode can be considered infinite, and if the concentration at its surface is 1 gr. equiv. in 1,000 litres, the capacity of the first electrode per sq. cm. at a temperature of 18° C. and for the case of $m = 200 \cdot 2\pi$ is 664·8 microfarads. This agrees well with experimental values.

Part of the polarisation is probably due to the solution of electrode metal in the electrolyte, which contains oxygen, since the current produces a change of concentration in this salt. If it is altogether due to this cause, C must be inversely proportional to the square root of the frequency, and ψ must be $= \pi/4$. This is fulfilled in the cases mentioned above, and approximately in the case of platinised platinum electrodes in NaCl solution, but not in the case of mercury or smooth platinum electrodes in aqueous solutions of salts of the lighter metals. Their anomalous behaviour should be investigated. E. E. F.

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708. *Reversible Electrodes.* **E. Neumann.** (Wied. Annalen, 67. 3. pp. 500–534, 1899.)—The authoress investigates theoretically and experimentally the polarisation capacity of electrodes immersed in a very dilute solution of their own salt, a more concentrated solution, having the same anion, being inserted between the two electrodes. Electric currents and diffusion produce displacements of concentration in the electrolyte, and these again produce polarisation of the electrodes. The capacity of polarisation is, by Warburg's theory—

$$C = \frac{c_0 \sqrt{k}\, q\, \epsilon^2\, w}{2R\, \theta \sqrt{m f}}$$

where c_0 is the initial concentration, k the diffusion constant ϵ the charge of a gramme-ion, w the valency of the metal, R the gas constant, θ the absolute temperature, and f the number of ions liberated by the dissociation of a molecule. The authoress tests the dependence of C upon (1) the frequency, (2) the concentration, (3) the current intensity. She also finds the absolute value of the phase displacement and of the capacity itself, and investigates the relation between the resistance and the frequency. The theoretical relations (1) and (3) are found to hold good in mercury, and approximately in silver, but (2) only up to certain concentrations. The absolute value of the phase-difference agrees best in the case of mercury, and that of the capacity in the case of silver. E. E. F.

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709. *Distributed Capacity in Alternating Current Circuits.* **C. F. Guilbert.** (Écl. Électr. 17. pp. 177–186, 1898.)—This article is too long and complicated to admit of a comprehensive abstract.

The method of imaginary quantities is used, and the problem resolves itself into the solution of a differential equation of the second order in which the variable time is absent. In concluding the article the author remarks that the use of imaginary quantities considerably simplifies the solution of the problem of uniformly distributed capacity. The method may be used to successfully attack some problems which would be very difficult, if not impossible, to attack by ordinary methods. W. G. R.

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710. *Blondel-Carpentier Hysteresis Tester.* **Armagnat.** (Ind Élect. 7. pp. 543–546, 1898.)—The specimen to be tested takes the form of circular discs having an external diameter of 55 mm., and an internal one of 38 mm., the number of discs being chosen so as to make up a total thickness of 4 mm. These discs are suitably supported on a vertical spindle provided with a pointer and helical spring, the latter being enclosed in an oil vessel which provides the necessary damping. A powerful U-shaped permanent magnet provides the field, the discs being placed between its poles. The air-gap is made sufficiently large to render the magnetic reluctance of the specimen negligible in comparison with it. When the magnet is rotated, the deflection of the pointer attached to the spindle supporting the discs affords a measure of the hysteresis loss. The instrument obviously measures the hysteresis loss in a *rotating* field. But by using a different form of support for the specimen, and giving the latter the form of rectangular strips, the loss in an *alternating* field may be determined as in the Ewing instrument. A. H.

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711. *Effect of Silicon on Permeability of Cast Iron.* **F. C. Caldwell.** (Elect. World, 32. p. 619, 1898.)— The author gives B–H curves for specimens of two brands of iron ("Rockford" and Bessemer) containing different amounts of silicon, and from these it appears that the addition of silicon, between the limits of 1·8 and 4·6 per cent., always increases the permeability, the increase following the straight-line law; this result holds up to about 3·5 per cent. of silicon for inductions up to 8,000. The following data, which refer to the "Rockford" iron, and which do not differ materially from those for the Bessemer iron, are taken from the curves accompanying the paper :—

B=	2,000		5,000		7,000		8,000	
% of silicon	1·8	4·4	1·8	4·4	1·8	3·4	1·8	3·4
H=	13	3·5	32·5	14	65	44	94	63

A. H.

712. *Magnetic Properties of Sheet Iron.* **W. Rohr.** (Elektrotechn. Zeitschr. 43. p. 712, 1898, also Écl. Électr. 17. pp. 448–449, 1898.)—Koepsel's method of tracing the curves of magnetisation is used and the results of a number of experiments are given. The losses per cycle by hysteresis and by Foucault currents are tabulated for maximum inductions varying from 2,000 to 9,000 c.g.s. The coefficient of Steinmetz over the same range is also given, and is practically constant.

J. B. H.

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713. *Plane Magnetisation of Pyrrhotine.* **P. Weiss.** (Comptes Rendus, 126. pp. 1099–1100, 1898.)—Pyrrhotine or magnetic pyrites is, like magnetite, a crystalline magnetic substance. The crystals are of hexagonal appearance, but less symmetrical. They are somewhat rare, and the finest come from Brazil.

The author finds that on bringing a crystal near a magnet the attraction is nil when the plane of the hexagonal base is presented normally to the lines of force, whereas the attraction is most marked for other orientations. There is, therefore, a direction in which magnetisation becomes impossible, and one is led to believe that the substance can only become magnetised in the plane which is perpendicular to this direction, which for the sake of brevity the author names the magnetic plane.

The author has carefully studied this property by means of induction experiments carried out by the ballistic method.

When compared to Brazilian pyrrhotine the pyrrhotines of other districts are weakly magnetic, and must be classed among magnetic substances of a different kind. The author is of opinion that a closer study of these substances will show that this property of magnetisation, reduced to one plane, can be applied to all the pyrrhotines. L. J. S.

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714. *Magnetostriction.* **H. Nagaoka** and **K. Honda.** (Phil. Mag. 46. pp. 261–290, 1898.)—This paper deals with (*a*) measurement of change of volume and length by magnetisation; (*b*) measurement of the effects of hydrostatic and transverse pressures and of longitudinal pull on magnetisation; (*c*) calculation of Kirchhoff's coefficients k', k'', and a comparison of theory and experiment.

The subjects of the experiment were an ovoid of Swedish iron, a cylinder of Lowmoor iron, and a nickel rod of square cross-section.

The experimental results are:—

1. Hydrostatic pressure produces decrease of magnetisation in iron.

2. Magnetisation in iron produces increase of volume.

3. Hydrostatic pressure produces small increase of magnetisation in nickel.

4. Magnetisation produces small decrease of volume in nickel.

5. In moderate fields the application of a longitudinal pull produces in iron an increase of magnetisation up to a critical value, after which it decreases until it is less than when the iron is unstretched.

6. Magnetisation produces increase of length in iron till it reaches a maximum when H is about 30, after which it gradually diminishes.

7. In moderate fields a longitudinal pull produces decrease of magnetisation in nickel up to a critical value, after which it gradually increases, but does not attain a value greater than when the nickel is unstretched.

8. Magnetisation produces continuous diminution of length in nickel.

The only serious discrepancy between theory and experiment occurs in 1. The result 4 is also discordant; but here the effects deduced from theory are so small as to fall within the range of experimental errors.

Illustrative diagrams and numerical tables accompany the paper. G. B. M.

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715. *Magnetic Susceptibility of Water.* **G. Jäger** and **S. Meyer.** (Wied. Annalen, 67. 2. pp. 427–429, 1899.)—An attempt is made to discover the cause of the discrepancy between the authors' value for the susceptibility of water and the values arrived at separately by du Bois ($-0{\cdot}837\times10^{-6}$ at 15°) and Koenigsberger ($-0{\cdot}79\times10^{-6}$ at 15°), who both used Quincke's method of capillary elevation. The discrepancy, however, remains unaccounted for, the value obtained after eliminating every conceivable source of error being $-0{\cdot}687\,(1-0{\cdot}0016t)\,10^{-6}$. E. E. F.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

716. *Microstructure of Alloys.* **J. E. Stead.** (Soc. Chem. Ind. Journ. 17. 1111–1116, 1898.)—Antimony and Tin.—The eutectic alloy containing $7\frac{1}{2}$ per cent. of antimony is a mixture of tin and the compound SnSb; its crystalline structure resembles that of tin. With larger proportions of antimony (up to about 40 per cent.) the compound SnSb separates out in what appear to be cubes embedded in the first-mentioned eutectic. From 57 to 100 per cent. of antimony crystals of this metal are found in a matrix of undecided composition. Between 40 per cent. and 57 per cent. of antimony the crystals are apparently transition products between SbSn and Sb.

Antimony and Copper.—These alloys are classified as follows: From 100 to 75·8 per cent. of antimony the alloys consist of crystals of antimony embedded in the eutectic alloy of antimony and the purple compound $SbCu_2$ containing 75·8 per cent. Sb and 24·2 per cent. Cu. From 75·8 to 48·5 per cent. of antimony, crystallites of $SbCu_2$ are found in increasing quantity, until finally a homogeneous mass of $SbCu_2$ is reached. From 48·5 to 38·57 per cent. of Sb the purple compound is gradually displaced by white crystals, which appear to be $SbCu_3$. From 38·57 to 31 per cent. of Sb (which latter appears to be a second eutectic) the phenomena do not admit of a simple interpretation. When the proportion of Sb is less than 31 per cent., definite yellow crystals appear, containing increasing proportions of copper, apparently most concentrated in the central parts of the crystal.

Copper and Tin.—The crystallites of apparently indefinite composition found in alloys containing from 3 to 34 per cent. of Cu contain two constituents, one of which is probably CuSn. T. E.

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717. *Etherion.* **W. Crookes.** (Chem. News, 78. pp. 221–222, 1898.)—It is surmised by Crookes from his former researches that the "new gas," first announced by C. F. Brush (see 1899, Abstract No. 325) at the Amer. Assoc. for Adv. of Sc., Boston, August 23, 1898, may be simply aqueous vapour. In 1873 he noticed that a little of this vapour thrown into the vacuum converted into attraction the repulsion produced by radiation (Phil. Trans. clxiv. 2, p. 515). In 1876 he described experiments confirming this result (Ibid. clxvi. 2, p. 329), which he more fully investigated in 1880–81 and 1886. He found that air-dry glass condenses on its surface a considerable amount of water and CO_2 which does not come off in vacuo till heat is applied, and that if the heat be raised with intervals of exhaustion, the vapours are continually evolved until the bulb collapses, when

the fused glass shows minute bubbles due probably to escaping vapour of water. Similarly, etherion is stated to be "absorbed by glass and re-evolved on heating in vacuo" (Chem. News, lxxviii., p. 197). Extracts are given from unpublished work, proving that, at high vacua, aqueous vapour, like "etherion," is a better conductor than air or H at the same pressures, while Brush has also found that his new gas is absorbed by phosphoric anhydride and by soda-lime. S. R.

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718. *Predictions of Neon.* **W. Sedgwick.** (Chem. News, 78. p. 293, 1898.)—The existence of a non-valent element of the at. weight of neon, alluded to as theoretically probable by Lord Lister (Roy. Soc., November, 1898), had been predicted earlier by the author (Chem. News, lxxi., p. 139; Force as an Entity, 1890, p. 61; Roy. Soc., November, 1892), from a consideration of the series:—

$$F^{i},\ 19;\ O^{ii},\ 16;\ N^{iii},\ 14;\ C^{iv},\ 12.$$

He had also suggested that the metallic series

$$Na^{i},\ 23;\ Mg^{ii},\ 24;\ Al^{iii},\ 27$$

pointed to a non-valent *metal* of the at. weight 20. He believes that in non-valent elements the form of the atom is a perfect sphere, and for valent atoms a sphere "with flat places in number corresponding with valency." "In the metalloid the flat places are cut down, so that the at. weight decreases as valency increases; in the metal they are built up" with the reverse effect, hence "the same non-valent element can give rise to both a metalloid and a metal series." J. Thomsen supports these conclusions from electrical considerations (Zeit. f. Anorg. Ch. ix. 28). With regard to Clerk-Maxwell's objection that the hard atom "fails to account for the vibrations of the molecule as shown in the spectroscope" (Art. "Atom," Encycl. Brit. 9th ed.), it is pointed out that, with an ether composed of two fluids, it is not necessary to refer the disturbance which gives rise to light to any vibratory movement in the atom. S. R.

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719. *Vapour Pressure of Co-existent Phases.* **M. Cantor.** (Wied. Annalen, 67. 3. pp. 683–689, 1899.)—If two liquids are mutually soluble to a limited extent, and the two saturated solutions are brought into contact, there is no mutual action. They form coexistent phases. An example is furnished by a saturated solution of ether in water and another of water in ether. Konowalow maintained that their vapours possess the same composition and the same vapour pressure. The author shows that

the experiments and considerations upon which that conclusion is based are inconclusive, and that the concentration of a body is greater in the vapour from the phase which contains it as a solvent. E. E. F.

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720. *Vapour Pressure of Crystallised Hydrates.* **G. Tammann.** (Zeitschr. Phys. Chem. 27. pp. 323–336, 1898.)—The author describes some more substances in which the vapour pressure changes in a continuous manner with the composition. Among these are omelinite from Victoria, chabasite from Faroer, okenite from Greenland, and pyrophyllite from Zermatt. Some uncrystallised substances, such as wood, albumen, and the zeolites, have the same property. Wood may be reckoned physically among the solid solutions, but gelatine and soap must be considered as very viscous liquid solution. E. E. F.

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721. *Molecular Weight of Liquids.* **D. Berthelot.** (Comptes Rendus, 128. pp. 606–609, 1899.)—By a combination of the results of Mathias with those of Amagat, the author arrives at the following formula, giving the molecular weight M of a liquid in terms of its density d at a temperature T, its critical temperature T_c, and critical pressure P_c (atmospheres):

$$M = 11{\cdot}4d\frac{T_c}{P_c\left(2-\frac{T}{T_c}\right)}$$

Tables of the calculated and observed molecular weights of 42 liquids are given, including chlorides, benzene derivatives, propyl, butyl, and ethyl salts, and the differences range from 1 to 5 per cent. The conclusion arrived at is that the great majority of bodies have the same molecular volume in the liquid and in the gaseous state. Only water and the fatty acids and alcohols are distinctly polymerised. E. E. F.

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722. *Osmotic Pressure and Thermodynamics.* **N. Schiller.** (Wied. Annalen, 67. 2. pp. 291–306, 1899.)—A mathematical investigation of the change of vapour pressure by external pressure on the surface; the heat of dilution; and the heat of solution of a gas absorbed by a liquid. E. E. F.

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723. *Diffusion of Gases in Liquids.* **G. Hüfner.** (Zeitschr. Phys. Chem. 27. pp. 227–249, 1898.)—In a previous paper (see

Phys. Soc. Abstracts, No. 149, 1897) the author showed that plates of hydrophane could be used to stop the ends of tubes containing the liquid into which the gas is to diffuse, thus preventing convection currents in case the liquid gets heavier by absorbing gas. He has since applied a similar method to the determination of the rate of diffusion of ammonia in water, for which Müller found an altogether anomalous value, four times the rate of hydrogen. Since the amount of gaseous ammonia contained in a capillary tube 1 m. long is only about one-eighth of the amount which a thread of water 1 cm. long is capable of absorbing, Stefan's capillary method is altogether excluded. The author employs a siphon-shaped tube attached to a U-tube. The latter serves as a manometer, and also contains a bulb to hold the gas. The former is narrower, and its outside arm is closed at the lower end with a plate of hydrophane, which acts as a support for a short water column. The coefficient of diffusion thus obtained is 1·250 at 20°, and 0·822 at 5°, which agrees well with Voigtlander's figures, and is even less than the theoretical value deduced from the density.

The author also describes experiments made with gases diffusing through agar-agar. E. E. F.

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724. *Solubility of Salts of Weak Acids in Stronger Acids.* **A. A. Noyes** and **D. Schwartz.**—(Zeitschr. Phys. Chem. 27. pp. 279–284, 1898.) The solubility of silver benzoate in pure water, and in solutions of nitric and chlor-acetic acids is measured and found to be in complete agreement with the theory developed by Noyes (Zeitschr. Phys. Chem. 27, p. 267, 1898). In all cases the product of the concentrations of the Ag and $C_6H_5CO_2$ ions remains constant. T. E.

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725. *Dissociation of Water.* **R. A. Lehfeldt.** (Zeitschr. Phys. Chem. 27. p. 94, 1898.)—The 10×10^{-27} gram-mol. of hydrogen per litre which Luther calculates, from measurements of E.M.F., to exist in saturated steam at 20° would correspond, according to the kinetic theory, to *one* molecule of hydrogen in 80 litres. The fundamental assumptions made in the calculations require examination. T. E.

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726. *Solubility and Heat of Formation of Electrolytes.* **G. Bodländer.** (Zeitschr. Phys. Chem. 27. pp. 55–74, 1898.)—Calling E the minimum E.M.F. required to decompose the saturated solution of a salt, E_a and E_k the E.M.F.'s required to separate its anion and kation respectively from their normal solutions, and c the concentration of the ionised part of the

salt in its saturated solution (measured in equivalents per litre), $E_s = E_a + E_k - k \log c$. When both ions are monovalent $k = 0{\cdot}116$, for one ion monovalent and the other divalent $k = 0{\cdot}087$, and for both ions divalent $k = 0{\cdot}058$. E_s may be calculated approximately from the heat of formation of the salt, preferably from solid constituents, since this is almost independent of temperature and therefore probably nearly equal to the free energy. For most sparingly soluble salts, c may be regarded as equal to the solubility. The values of the solubilities of a large number of salts calculated in this way from the existing, somewhat inaccurate, data, are always of the same order of magnitude as the observed solubilities, the concordance being in some cases close. The empirical rules that the solubility of different salts of the same metal (or acid) is greater, the greater the tendency of the acid radical (or metal) to pass into the ionised condition are in full agreement with the above equation, and the exceptions to these rules, are shown to be necessary consequences of it. T. E.

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727. *E.M.F. between Amalgams.* **H. P. Cady.** (Journ. Phys. Chem. 2. pp. 551–564, 1898).—The author has verified the conclusion that the E.M.F. of amalgam cells is independent of the solvent and concentration of the solute, but varies inversely as the valency of the metal in the electrolyte. With amalgams of the alkalies and alkaline earths abnormal results are obtained which are in harmony with Ramsay's observations on the vapour pressures of these amalgams. The value of an E.M.F. is given in general by the Helmholtz equation: in the case of amalgam cells, the heat of reaction is assumed to be zero, and the E.M.F. to be consequently given by the temperature coefficient only. The author finds that the heat of reaction cannot always be neglected, because the heat of dilution is sometimes considerable. When this is taken into account, the above results probably become normal: in the case of sodium, this view was shown experimentally to be correct. The van't Hoff-Raoult formula, $n/N = RT \log (p/p_1)$, holds theoretically only when the heat of dilution is zero. The equation for concentration cells should be written $E = q \times 0{\cdot}0002 \frac{T}{n} \log_{10} \frac{c_1}{c_2}$, in which q is the heat of dilution. W. R. C.

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728. *Liquid Cells and Ionisation of Fused Salts.* **C. McC. Gordon.** (Amer. Acad. Proc. 33. pp. 59–68, 1898.)—The author has measured the E.M.F. of liquid cells consisting of silver electrodes dipping into "solutions" of different concentrations of fused silver nitrate. The solvent was a mixture of fused potassium and sodium nitrate. In the cases where the concen-

tration of the silver nitrate was small, the actual results agree with those calculated from the Nernst formula, which is usually applied to cells containing aqueous solutions. As the concentration is increased, there is a marked divergence, which the author explains by assuming that the salt is not completely ionised. Regarding this divergence as a measure of the incompleteness of ionisation, the author concludes from measurements made upon a cell containing 100 per cent. and 50 per cent. "solutions" respectively about the electrodes that pure fused silver nitrate is ionised to the extent of 58 per cent. W. R. C.

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729. *Heat of Solution and Solubility of Electrolytes.* **J. J. van Laar.** (Zeitschr. Phys. Chem. 27. pp. 337–342, 1898.) The author replies to Noyes' criticisms. (See 1899, Abstract No. 149.) T. E.

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730. *Heat of Solution, Ionisation, and Solubility of Electrolytes.* **A. A. Noyes.** (Zeitschr. Phys. Chem. 28. pp. 431–438, 1899.)—A continuation of the above discussion with van Laar. Incidentally the following expression for the heat of ionisation of an electrolyte following an empirical law of dilution $\frac{x^{\nu}}{(1-x)\,v\,(\nu-1)} = K$, is obtained:—

$$\frac{Q}{RT^2} = \frac{n-1}{\nu-1} \cdot \frac{d \log K}{dT},$$

where x is the fraction of the salt ionised and n the number of ions into which it dissociates, ν an empiricial exponent and Q the heat of ionisation. T. E.

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731. *Ionising Power of Solvents.* **L. Kahlenberg** and **A. T. Lincoln.** (Journ. Phys. Chem. 3. pp. 12–35, 1899.)—The ionising powers of solvents run parallel, according to Nernst, with their dielectric constants; according to Dutoit and Aston, the molecular association, and according to Brühl the presence of elements possessing unsaturated valencies conditions dissociative power. Qualitative observations on the presence or absence of conductivity in solutions of $FeCl_3$, $SbCl_3$, $BiCl_3$, and $HgCl_2$ in 72 organic solvents show that, with one or two exceptions, Nernst's rule is in agreement with the facts. On the other hand, solutions in many non-polymerised solvents conduct well, whilst those in solvents having unsaturated valencies frequently do not. Quantitative determinations indicate more or less electrolytic dissociation; in some cases chemical action occurs between solvent and dissolved substances. Cryoscopic determinations with nitrobenzene as solvent give molecular weights above the theoretical values for $FeCl_3$, $SbCl_3$, and $SnCl_4$, below them for $AsCl_3$, $BiCl_3$,

and PCl_3. The fact that a solution of picric acid in benzene is a non-conductor is against Konowalow's view that combination of solvent and solute conditions conductivity. T. E.

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732. *Ionic Migration in Dilute Solutions.* **W. Bein.** (Zeitschr. Phys. Chem. 27. pp. 1–54, 1898.)—The most important source of error in determinations of the relative velocity of the ions by means of measurements of the changes of concentration at the electrodes is the diffusion of the products formed by the electrolysis away from the electrodes under the influence of the electric current. A very complete discussion of this source of error is given. The ordinary diffusion of the products of electrolysis into the solution is very slow and quite unimportant compared with the electrolytic diffusion. The presence of membranes influences the velocities of different ions to a different extent, and is therefore inadmissible in accurate determinations. Solid particles deposited near the electrodes are somewhat rapidly distributed by the current throughout the solution, and may render the results erroneous. When a cadmium anode is used a film of basic cadmium salts may be formed on it, making the concentration of the anode solution too small. Several other minor sources of error are discussed and five different forms of apparatus described. In these the anode and kathode solutions are kept separate by placing them sufficiently far apart. The principal results of the 174 determinations made are as follows (n is the transference ratio for the anion):—

HCl. Within the limits of experimental error n is independent of the concentration from 1/200 N to 1/5 N; its value at temperature t° is $n_t = 0{\cdot}157 + 9 \times 10^{-4}\, t$.

NaCl. In this case also n is independent of the concentration between 1/200 N and 1/3 N; its value is $n_t = 0{\cdot}622 - 7{\cdot}4 \times 10^{-4}\, t$.

KCl. Between 1/100 N and 1/5 N, n is independent of the concentration. At 11°, $n = 0{\cdot}503$; at 76°, $n = 0{\cdot}513$.

H_2SO_4. In a solution containing 0·24 per cent. of H_2SO_4 the values of n at different temperatures are given by the expression

$$n_t = 0{\cdot}160 + 15 \times 10^{-4}\, t.$$

Determinations are also made with solutions of the chlorides of lithium, ammonium, rubidium, cæsium, thallium, calcium, barium, cadmium; silver acetate and nitrate, copper sulphate and chloride, the chlorides of strontium, magnesium, manganese, and cobalt; sodium bromide, potassium iodide, nitric acid, sodium nitrate, thallium sulphate, magnesium sulphate, sodium carbonate, potassium carbonate; sodium, ammonium and calcium hydroxides, potassium permanganate, and oxalic and succinc acids, for the results of which the paper must be consulted, as also for a few experiments with concentrated solutions. T. E.

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733. *Electrolytic Conduction under Pressure.* **A. Bogojawlensky** and **G. Tammann.** (Zeitschr. Phys. Chem. 27. pp. 457–473, 1898.)—The authors investigate the influence of pressure upon the conductivity of polyvalent ions, and also the manner in which that influence is affected by concentration, change of volume, and degree of dissociation. The conductivity λ of a solution is proportional to the number of ions in unit of volume, and inversely proportional to the ionic friction. By raising the external pressure p (1) the volume v of the solution is diminished, and hence the concentration is increased; (2) the viscosity, and consequently also the ionic friction, is increased; (3) the degree of ionisation α of the solute is changed; (4) the degree of ionisation α^1 of the solvent is also changed, according to the equation

$$\frac{1}{\lambda}\frac{\Delta\lambda}{\Delta p} = \frac{1}{v}\frac{\Delta v}{\Delta p} + \frac{1}{\eta}\frac{\Delta\eta}{\Delta p} + \frac{1}{\alpha}\frac{\Delta\alpha}{\Delta p} + \frac{\lambda}{\lambda^1}\frac{1}{\alpha^1}\frac{\Delta\alpha^1}{\Delta p}$$

where λ^1 is the conductivity of the solvent. The author proceeds to discuss the separate terms of this equation, and compares their experimental values with the formulæ given by various authors. As regards solutions containing more than monovalent ions he finds that dissociation does not equally affect the several hydrogen atoms in the molecule. It is always one particular hydrogen atom which is separated out first as an ion, and such ions probably often exceed the next set of hydrogen atoms more than a hundred times in number. As regards the manner in which the influence of pressure depends upon the degree of ionisation, Planck's formula

$$\frac{d \log k}{dp} = -\frac{\Delta v}{1{,}000\ RT}$$

is practically verified.

The experiments were made with a special bulb cell enclosed in a cast-iron pressure cylinder capable of withstanding 500 atmospheres. Among the bodies experimented upon were water, HCl, NaCl, acetic, chloracetic, and phosphoric acids, ammonia, sodium phosphate and tartrate, and citric acid. E. E. F.

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734. *Drop Electrodes.* **G. Meyer.** (Wied. Annalen, 67. 2. pp. 433–438, 1899.)—Experiments with a fine jet of mercury or amalgam made to fall through various salt solutions lead to the following views: If the metal possesses the property of condensing the salt on its surface, the concentration of the solution in the neighbourhood of the jet is diminished. The condensed salt collects over the metal surface upon which the jet impinges and there the concentration is increased, but no metal goes into solution. If, however, the metal of the jet does not condense

the salt, some of the metal itself is dissolved. This explains all Palmaer's observations, which need therefore not be taken as confirming Nernst's theory of drop electrodes. E. E. F.

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735. *Electrolytic Formation of Alums.* **J. L. Howe** and **E. A. O'Neal.** (Chem. News, 78. pp. 236–237, 1898.)—A number of alums containing iron, cobalt, and chromium were prepared by electrolysis of solutions of metallic sulphates, strongly acidified with sulphuric acid. The anode consisted of a platinum dish resting on a coil of copper wire, whilst the kathode was a coil of heavy platinum wire dipping into a porous cell; the current usually employed was that yielded by four Bunsen cells. The iron-rubidium, iron-cæsium, cobalt-rubidium, and cobalt-cæsium alums, which have not previously been described, were obtained in the pure state and analysed. No alums of manganese or ruthenium could be obtained by the above method. N. L.

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736. *Efficiency of Electrolytic Processes.* **R. Moritz.** (Ind. Électrochim. 2. pp. 49–51, 1898.)—A short exposition of the theory of electrolytic dissociation. Secondary reactions are explained with regard to the electrolysis of NaCl. The liberated Na yields with water NaOH and H_2. The former is electrolytically dissociated into Na^+ and $\overline{OH}$; the OH goes to the anode, where it is discharged, and combines with the chlorine to ClOH, which is again an electrolyte with the ions $Cl\bar{O}$ and H^+. The ClO is liberated as Cl_2+O_2. The energy relations are not discussed. H. B.

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737. *Diaphragms for the Electrolysis of the Alkali Metal Chlorides.* **H. Becker.** (Ind. Électrochim. 2. pp. 41–42, 1898.)—A continuation of an earlier article (see 1898, Abstract No. 1079.) The patents of Hoefner, the An. Salines domaniales de'l'Est, Beim, Marx, Stoerner, Comboul, Greenwood, and of Bamberg are briefly described. Mica, lime, magnesia, various liquids, and mechanical devices are recommended in these patents as materials for diaphragms. The article does not admit of a useful abstract. J. B. C. K.

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738. *Becker's Method of Copper Deposition.* **E. Ronco.** (Ind. Électrochim. 2. pp. 92–93, 1898.) After describing the defects of the methods of Cowper-Coles and of others, the author

gives details of the improved method of Becker. Copper is used as kathode material. This is prepared for use by depositing a coat of silver upon both faces, and by burnishing this deposit, first in the usual manner, and finally with dry precipitated sulphur, until a brilliant golden tint has been produced. This silver-coated kathode is then fixed in a frame of some insulating material, and is again hung for a short time in the silver depositing bath. It is then momentarily dipped in water containing 1 gramme nitric acid per litre, and without washing is transferred to an electrolytic bath containing copper sulphate as the electrolyte. By observing the usual precautions for the deposition of dense and adherent copper, a sheet is obtained which is covered on the one side with an adhesive coating of silver of splendid brilliancy, capable of any use to which rolled copper may be put. The cost of production is stated to be 3f. per kilo, while the selling value is from 8f. to 12f.

In a future article the author promises details of some of the articles made from this silver plate. J. B. C. K.

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739. *Sugar Refining by Electrolysis and Ozone.* F. Peters. (Zeitschr. Elektrochem. 5. pp. 265–269, 1898.)—Hagen, Depeissis, and Fahrig have proposed the use of ozone for sugar refining, while Schollmeyer and Dammeyer were the first to experiment with electrolytic methods for attaining the same end.

The author has investigated the results obtained when using first, ozone alone, secondly, electrolysis alone, and finally when using these two purifying agencies in combination. A Siemens ozoniser was used to produce the ozone for these trials.

An optical method was used for comparing the sugar juices after treatment. It was found that electrolysis and ozone in combination were more effective than either agency alone.

A useful tabular summary of the results is given ; but the investigation did not extend to the question of comparative costs.

J. B. C. K.

GENERAL ELECTRICAL ENGINEERING.

740. *O'Keenan's "Endoxyque" Battery.* (Ind. Élect. 7. pp. 430–433, 1898.)—This cell consists of a zinc positive and a lead-lead sulphate negative in a solution of zinc sulphate. The special feature of the combination is the negative element, which is substantially the same as a fully discharged negative electrode of a lead accumulator.

A plate of electrolytically reduced spongy lead is exposed to the air till thoroughly oxidised and then immersed in dilute sulphuric acid to sulphate it. After rinsing in water to remove excess of acid it is ready for use.

During the working of the cell the lead sulphate is reduced to spongy metal, and it is regenerated by again putting through the above cycle of operations. The E.M.F. of the combination is about ·5 volt. Details are given of the mounting and arrangement of the plates and figures as to outputs and cost of working.

E. J. W.

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741. *Electrical Stage-appliances at Drury Lane Theatre.* (Electrician, 42. pp. 325–326, 1898.)—In this installation, which was designed by Mr. Edwin O. Sachs, the stage is divided into six large sections, each $40' \times 8'$, of which two are raised and lowered in guides through 19′, by electric power. These sections or lifts comprise two steel-arched lattice girders braced together, $5'\ 6''$ apart, weighing $4\frac{3}{4}$ tons, and with the joists and flooring, between 6 and $6\frac{1}{2}$ tons, of which 4 to $4\frac{1}{2}$ tons are counterbalanced. Each lift is operated by a $7\frac{1}{2}$ H.P. four-pole, enclosed, shunt-wound motor running at 520 rev. per min., connected through worm-gearing (104 : 1) to a shaft carrying two winding drums making 5 rev. per min. Steel wire ropes pass from these drums over guide-pulleys to the four corners of the lift, the speed of lifting being 16′ per min. A crab is combined with the drum shaft, so that it can be easily thrown into gear in the event of failure of the current, &c. The work was carried out by the Thames Ironworks Co.

C. K. F.

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742. *Improved Prony Brake.* A. Wetler. (Elektrotechn. Ztschr. 19. p. 658, 1898; also Écl. Électr. 17. pp. 290–292, 1898.) In this brake the action of a weight on an arm attached to the friction-blocks is assisted by a special form of spring balance, which is connected to a second arm also attached to the friction-blocks. By measuring the angle through which the arms are turned from a given position (*e.g.*, both arms horizontal), the torque for any given angle can be calculated from a formula, or,

by constructing curves, the torque can be obtained directly. Drawings and a diagram of the apparatus are given in the original paper. C. K. F.

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743. *Le Roy's Electric Heating Apparatus.* **J. Reyval.** (Écl. Électr. 17. pp. 154–159, 1898; 14. p. 317; Mém. de la Soc. des Ing. civils de France, Feb., 1898, pp. 236–237.)—The essential part of these heaters consists of a rod of agglomerated silicon, as pure as possible; the two ends of the rod are coated with metal and clamped in copper sheaths; the rod is enclosed in an exhausted glass tube having metal caps at its ends, adapted to fit into spring clips, forming the terminals, whereby current is supplied to the heater. The heater reaches a temperature of 700° to 800° C. in two to three minutes. The resistivity of silicon is very high (see 1898, Abstract No. 408), thus making it a very advantageous material for this purpose. Each tube will last from 800 to 1,500 hours and costs 5f. In a linen stove having four of the heaters above described, and supplied with an alternating current at 110 volts, the temperature was raised from 25° to 70° C. in a quarter of an hour, using 137 watt-hours, each tube requiring 135 to 150 watts to maintain it at its normal temperature. C. K. F.

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744. *Mechanical Application of Electricity.* **G. Richard.** (Écl. Électr. 17. pp. 261–271, 1898.)—This is a description of some controllers and transmitters. W. G. R.

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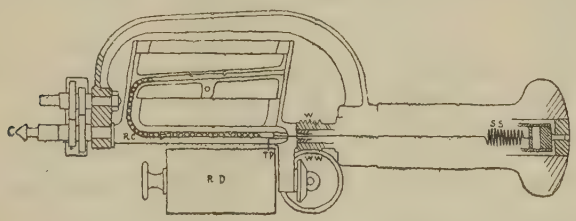
745. *New Apparatus for Measuring Torque.* **Boucherot.** (Soc. Int. Elect. Bull. 15 pp. 474–481, 1898.)—The apparatus described is extremely convenient for determining the relation between the speed and torque of a motor. The essential parts are shown in the accompanying sketch. A roller chain RC is fixed at one end to a tracing-point TP, which presses against the recording drum RD, and to a spiral spring SS. The far end of the chain is free. This chain is capable of sliding in a U-shaped groove or channel. When the centre C of the instrument is applied to the shaft of a motor, the frame containing the chain is set in rotation, and the centrifugal stress due to the radial portion of the chain causes an extension of the spring and a consequent displacement of the tracing-point. This displacement is proportional to the square of the angular velocity, since the mass of the radial portion of the chain remains constant. In order to counteract the friction due to the pressure of the chain against the outer wall of the upper part of the groove, this part is made slightly sloping. A reduction of the speed is obtained by means of the gearing shown at the left-hand side of the sketch. While

the frame carrying the chain and the recording drum is rotating, the drum itself is receiving a slow motion of rotation round its own axis by means of bevel-wheels and a worm-wheel WW, which gears into a worm W fixed to the handle of the instrument. The curve traced out by TP on the paper coiled round the drum is therefore one whose abscissæ are proportional to total angular distance θ swept out by the rotor of the motor, and whose ordinates are proportional to ω^2, where ω is angular velocity. Let now I stand for moment of inertia of rotor, and T for the torque



exerted by it. Then—assuming no load on the motor, and neglecting frictional resistances—

$$T = I\frac{d\omega}{dt} \text{ so that } T\omega dt = I\omega d\omega, \text{ or } T = \tfrac{1}{2}I\frac{d(\omega^2)}{d\theta}.$$

Since $d(\omega^2)/d\theta$ may be obtained from the curve, we have at once a method of studying the variation of T with ω. The instrument is particularly valuable in testing induction motors: it may also be used in Routin's method of testing dynamos. (See 1899 Abstract, No. 199.) In order to find I, we may either actually measure T for one particular speed, or, keeping T constant, attach to the rotor a body of known moment of inertia. The instrument measures 30 cms. in length, and is made by Breguet. A. H.

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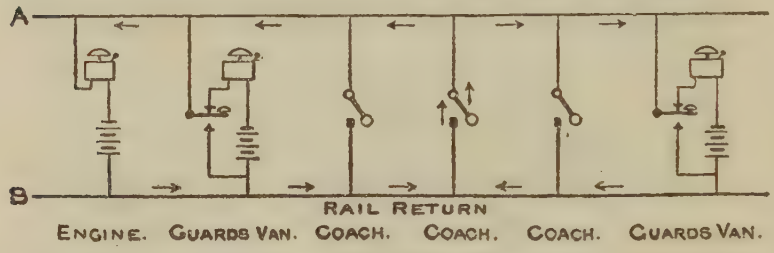
746. *Electric Intercommunication in Railway Trains.* **W. E. Langdon.** (Instit. Elect. Engin. Journ. 27. pp. 741–776, 1898. Discussion pp. 776–795, 1898.)—The author gives a historical summary of the subject, and describes the chief systems in use. Almost all are based on that devised by W. H. Preece, in which equal batteries are placed in the vans in series with bells, as shown in the annexed diagram, so that if any connection is made between the + and − conductors (A, B), all the bells are set ringing. Thus any passenger can call the attention of the guards, and the guards can signal to one another and to the driver. An insulated return is preferred to the use of the rails. Various methods of electrically coupling the coaches together are discussed; it is stated that the electrical and brake couplings should be entirely distinct. Interchangeability of the rolling stock of different railways is essential. The switches

and indicators used in the coaches are dealt with in detail. The paper concludes with extracts from the Report of the Committee appointed by the Board of Trade to investigate the subject.

The discussion dealt chiefly with details. **W. Leonard** stated that a separate indicator for each compartment was desirable, and that a combined electrical and brake coupling was to be preferred. **W. H. Winter** called attention to a system successfully applied



on the Madras Railway, in which the side chains form the electrical connections. **F. Hollins** described the combination coupling in use on the Great Eastern Railway. A. H. A.

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747. *Wiring Rules.* **J. Pigg.** (Instit. Elect. Engin. Journ. 28. pp. 122–141, 1899. Discussion pp. 142–165, 1899.)—The discrepancies between the rules issued by the various Fire Offices Supply Companies and the I.E.E. are set forth in detail, and curves plotted showing the insulation resistance per lamp required under the various rules for different numbers of lamps fixed. The maximum discrepancy appears where 150 lamps are fixed, when the required figure for 110 volts varies from less than 7 megs. per lamp according to the Liverpool, London and Globe Office and the Board of Trade, to over 110 megs. per lamp according to the Westminster Electric Supply Company. In Appendix I. are given the rules of the various Fire Offices and Supply Companies, and in Appendix II. their insulation requirements. This paper was discussed with that given in the following abstract. E. H. C.-H.

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748. *Regulation of Wiring Rules.* **C. H. Wordingham.** (Instit. Elect. Engin. Journ. 21. pp. 166–173, 1899.)—Rules for securing efficient and safe wiring are essentially different from those securing satisfactory utilisation of the public supply. The standard set of the former should be of universal application, but the Supply Companies' regulations could at most be based on a model set. The Electric Lighting Acts do not give satisfactory powers for enforcing rules, and Glasgow, Manchester, &c. have obtained special Parliamentary powers for this purpose.

Fittings should be carefully supervised. At Manchester they now test and certify samples of fittings, thereby benefiting both consumer and manufacturer. The tests for a fuse are that when complete in position on the mains it shall break the current when it is short-circuited through a fuse-wire corresponding to its rated capacity. A switch has to break a current 50 per cent. above its rated capacity at 50 per cent. above its intended voltage. The author suggests the testing of fittings in a similar manner by some central authority, such as the I.E.E., whose certificates would enhance the value of fittings, and so enable manufacturers to willingly pay fees for the tests. As regards Supply Companies' rules, much can be said for and against earthing the middle wire at the generating station, but it should not be earthed at consumers' premises. Otherwise, if heavy local currents are flowing down the middle wire, currents will be set up from one consumer's earth wire to another's, with serious electrolytic results. For isolated installations, however, and for house-to-house transformer systems, there is much to recommend an earth return.

Discussion (pp. 175–191, 1899). **R. E. Crompton** advocated the adoption of the I.E.E. rules issued in July, 1897, as the standard to be prescribed by consumers, insurance companies and municipal authorities, and to be worked to by contractors. **B. Drake** attributed the comparative failure of the I.E.E. rules to the insurance inspectors wishing to have rules differing from those of other people. As an instance of disagreement, he quoted the regulations relating to fuses in ceiling roses; some rules require them, others forbid them. **F. Bathurst** criticised C. H. Wordingham's remarks on earthing, and questioned the occurrence of electrolytic troubles. If they did arise, the station engineer's duty would be to obviate them by developing his mains system, rather than to give up a cheap and reliable system which could compete with gas-piping in point of cost. **J. S. Raworth** objected to municipalities being given further dictatorial powers as to fittings. **C. Bright** pointed out that specific resistance *per se* is little indication of lasting good qualities in a dielectric: a prolonged insulation test by direct deflection is more valuable. **F. G. Baily** emphasised the unreliability of ordinary insulation tests of an installation. On a damp day in a new building, where porcelain has been extensively used it is difficult for the best work to give a satisfactory test. **M. O'Gorman** doubted if the I.E.E. rules would bear literal enforcement. Many recognised and admittedly safe systems would fail to comply with them. For wires, long immersion tests should be made: a good mechanical test with a low uniform and permanent electrical test is far superior to a poor mechanical result with high temporary megohms. He suggested alterations in detail to many of the I.E.E. rules. E. H. C.-H.

GENERATORS, MOTORS, AND TRANSFORMERS.

749. *Graphical Study of Shunt-wound Dynamo and Motor.* **Della Riccia.** (Bull. Ass. Ing. Él Liége, 9. pp. 413–463, 1898.) —The starting-point of the methods described in this paper is what the author terms the "principal" characteristic, *i.e.*, the curve connecting exciting current with E.M.F. on open circuit. When the machine is running loaded, the author regards its E.M.F. e as being made up of the sum of two terms; one e_f, which is due to the field-magnets, and which represents the E.M.F. on open circuit, corresponding to the exciting current actually traversing the field coils; and another, e_a, which is due to armature reaction; so that $e = e_f - e_a$. The term e_a increases with the load, and although not strictly proportional to the armature current, may be assumed to be so over the range of the principal characteristic used in practice. Hence, if v stand for the potential difference between the terminals, $v = e_f - (r_a + \rho) i_a$, where r_a and i_a stand for armature resistance and current respectively, and ρ is a constant (approximately) which represents the demagnetising effect due to the armature current. Assuming that the principal characteristic is given, and that the values of r_a, ρ and the shunt resistance and turns are known, the author shows how the ordinary characteristics may be deduced by a graphical construction from the principal one, and how the same graphical method may be applied to the solution of a large number of problems in connection with the shunt-wound dynamo and motor. A. H.

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750. *Armature Design.* **G. Grassi.** (Atti Della Assoc. Elettrotechnica Italiana, vol. i. p. 41; also Écl. Électr. 17. pp. 295–296, 1898.)—This article shows how to calculate the proper dimension of any new type of armature where it is impossible to refer to past experience.

If l is the length, d the diameter of the armature B the induction in the armature, and ϕ the total flux, then—

$$\phi = \beta \, l \, d \, \mathrm{B}$$

where β is a coefficient less than unity.
Also the volts generated are given by—

$$e = \frac{\mathrm{N} \, n \, \phi}{30} \, 10^{-8}$$

where N is the number of convolutions of wire on a two-pole drum wound armature, and n the number of revolutions per minute. If v is the linear velocity of the circumference, then—

$$v = \frac{\pi \, d \, n}{60}$$

whence— $$e = \frac{2}{\pi} \beta \, l \, \mathrm{N} \, \mathrm{B} \, v \, 10^{-8}$$

The ratio of the power lost in the armature to the total power generated is given by—

$$\gamma = \frac{r\,i}{e},$$

where i is the total current and r is the armature resistance; γ should not exceed 0·02.
Also—

$$r = \frac{1}{4}\rho\frac{2\,(l+d)a}{s}\mathrm{N},$$

where s is the sectional area of the wire, ρ its specific resistance, and a a coefficient greater than unity. If q is the current density in the wire then—

$$i = 2sq,$$

whence—

$$\gamma = \frac{\pi}{2}\frac{\rho\,a\,q}{\beta\,\mathrm{B}\,\nu}\left(1+\frac{d}{l}\right)10^{8},$$

or—

$$\frac{d}{l} = \frac{2\beta\,\gamma\,\nu\,\mathrm{B}}{\pi\,\rho\,a\,q}10^{-8} - 1,$$

whence—

$$\gamma > \frac{\pi\,\rho\,a\,q}{2\,\beta\,\nu\,\mathrm{B}}\,10^{8}.$$

Suppose that a cooling surface of m centimetres per watt is allowed, then—

$$\pi\,l\,d = m\,\gamma\,e\,i = m\,\gamma\,\mathrm{W}$$

W being the output of the dynamo.
We are then led to the relation—

$$d^2 = \frac{m\,\gamma\,\mathrm{W}}{\pi}\left\{\frac{2\beta\,\gamma\,\nu\,\mathrm{B}}{\pi\,\rho\,a\,q}10^{-8} - 1\right\}$$

or—

$$d = \mathrm{A}\,\sqrt{\mathrm{W}}$$

Where A depends on the induction, the peripheral speed, the current density, and the coefficients a, β and m. Applying this result the author obtains, for—

$\gamma = 0{\cdot}01$	$\frac{d}{l} = 0{\cdot}19$
$\gamma = 0{\cdot}15$	$\frac{d}{l} = 0{\cdot}785$
$\gamma = 0{\cdot}02$	$\frac{d}{l} = 0{\cdot}38$

W. G. R.

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751. *Effect of Commutation on Field of Dynamo or Motor.* **W. H. Everett** and **A. H. Peake** (Electrician, 42. pp. 328–329, 1898).—(See Science Abstracts, vol. i. p. 362, No. 708, 1898.) The article gives the results of an investigation undertaken to determine in how far the changes of current taking place in the short-circuited coil of a dynamo or motor at the time of commutation affect the main field of the machine. The method adopted consists in using an exploring coil of fine wire wound on one of the armature coils, one end of this exploring coil being connected to a slip-ring, and the other to a revolving adjustable contact-maker. By this means the instantaneous E.M.F. (which is proportional to the field) corresponding to any portion of the coil could be determined. The field is found to be affected by the change of current in the coil under the brush, as is shown by the ripples in the curves obtained. A. H.

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752. *Commutator Motors for Alternating Currents.* **G. Moulun.** (Écl. Électr. 17. pp. 465–473, 1898.) This is a lengthy mathematical discussion of the theory of the action of a four-pole series-wound motor when traversed by alternating currents. The field-magnets are well laminated, but otherwise the motor appears to be constructed as if for direct currents. Special attention is given to the action of the coils short-circuited by the brushes, and to the effect produced by altering their lead or lag. Formulæ are developed for the torque, output, efficiency, power factor, &c. of the motor; and these are worked out numerically from data taken from a 1 H.P. motor of the type referred to. The numbers so calculated agree very well with experimental results. The efficiencies given are fairly good for a 1 H.P. motor, but no data are given enabling one to compare the size and cost of this motor with those of a direct current motor of equal power. W. E. S.

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753. *Görges Phenomenon and Tandem Coupling of Induction Motors.* **F. Eichberg.** (Zeitschr. Elektrotechn. Wien, 16. pp. 578–582 and 591–594, 1898.)—In 1896 Görges noticed certain peculiarities in the behaviour of a polyphase induction motor provided with a rotor having a single-phase or uni-axal winding, such as, *e.g.*, a single short-circuited turn of conductor round the rotor core. Such a motor, when working under maximum load, was found to run at a speed not much below *half* the speed of synchronism, and to give an efficiency of some 70 per cent. (instead of the 50 per cent. which an ordinary motor would give at that speed). When the rotor was driven at a somewhat higher speed than half that of synchronism, the machine acted as a generator; but when run up to a speed not far removed from that of synchronism, the rotor once more acquired a positive torque,

and could support a moderate load. At a later date the same effects were observed by Görges and others in the case of single-phase motors with a uni-axal rotor winding.

The author attempts an explanation of this puzzling phenomenon, and adopts the following method: Assuming, for the sake of simplicity, a two-pole rotating field, let the simple loop or coil which forms the rotor winding be replaced by two pairs of coils at right angles to each other, as shown in Fig. 1, and let the coils I, 1 each convey half the ampere-turns corresponding to the original loop, and co-phasal with them, while the coils II, 2 convey the same ampere-turns as I, 1, but in quadrature with them and in opposition of phase to each other. The magnetic effect is obviously the same as that actually due to the single loop. Let n = frequency of supply, m = speed of

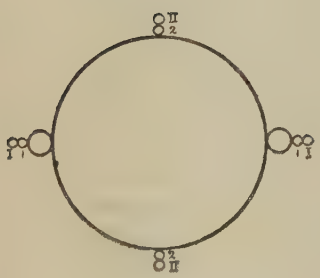

Fig. 1.

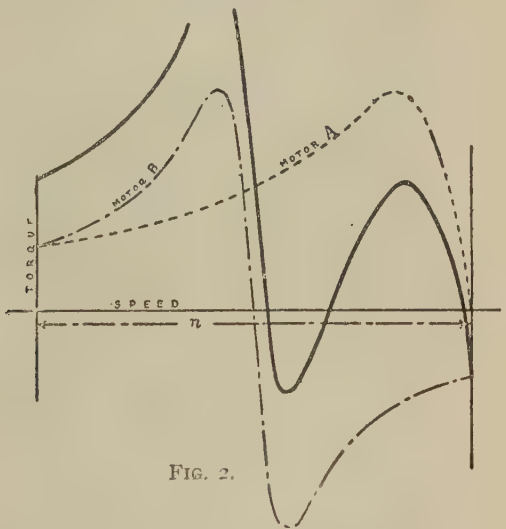

Fig. 2.

rotor, in revs. per sec. If the coils I, II, and 1, 2 be supposed placed on independent cores, the arrangement is equivalent to two ordinary polyphase motors, A and B, mechanically coupled, and electrically coupled, thus: The inducing winding of motor A is the field-winding of the actual motor, the frequency being n; the currents in the induced winding of A (coils I, II in Fig. 1) are of frequency $n-m$, and are the same as the currents in the inducing winding of B (1, 2 in Fig. 1), but with the connections interchanged, so that the field rotations are in opposite directions; the induced winding of B consists of the inducing or field winding of A, together with the whole of the supply network. The actual torque of the real motor is the algebraical sum of the torques of the imaginary motors. The torque-speed curves of these motors are shown (dotted and chain-dotted respectively) in Fig. 2, and from them is obtained the

full-line curve, which gives the actual torque of the motor. The shape of this curve at once explains the apparent anomalies in the behaviour of the motor. The same method is applied by the author to the case of a single-phase motor. The problem of two motors coupled tandem, which is suggested by the above considerations, is also discussed. A. H.

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754. *Langdon-Davies Single-Phase Motor.* (Electrician, 42. pp. 187–189, 1898.)—This article contains an illustrated description of the motor. The rotating part consists of a laminated core with a number of short-circuited coils wound on it. The stator is provided with two windings, one of which is always in action, while the other is only used at the moment of starting. There are no rubbing contacts of any description. The starting-switch is of the change-over type, the connections being so arranged that in the "starting" position the starting winding of the stator is directly across the mains, while its running winding is across the mains through a non-inductive resistance. Throwing over the switch connects the running winding directly across the mains, and disconnects the starting winding. Each motor is fitted with a double-width pulley, so as to enable it to start on a loose pulley on the counter-shaft. The following table gives the results of tests on three different sizes of this type of motor, at 100 volts and 87 ∩∪ per sec. :—

Output of Motor.	¼ Load.		½ Load.		¾ Load.		Full Load.	
	% Effy.	Power Factor.	% Effy.	Power Factor.	% Effy.	Power Factor.	% Effy.	Power Factor.
1 B.H.P.	35	·35	51	·47	57	·58	59	·67
4 ,, ,,	62	·39	74	·59	76	·73	72	·79
20 ,, ,,	54	—	73	—	77½	—	78	—

A. H.

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755. *Braking of Single-Phase Induction Motors.* F. Eichberg. (Zeitschr. Elektrotechn. Wien, 16. pp. 541–544, 1898.)—Given a single-phase induction motor running at its normal speed, what electrical methods are there for rapidly reducing it to rest? The question is at present of theoretical rather than practical interest, and the author offers the following two solutions: 1. Introducing resistance into the armature circuit; the most powerful braking action is obtained when the total resistance of the armature

circuit equals double its reactance; 2. Suddenly increasing the number of field-poles, or connecting the motor to supply mains of lower frequency—either of which will render its speed greater than that of synchronism, and introduce a powerful retarding torque. The second method, however, can only be used down to a certain speed, for below this the torque of the motor again becomes positive. A sketch of the theory of the two methods, with graphical illustrations, and an account of some simple experiments on the first method are given in the paper.

A. H.

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756. *Starting Devices for Motors.* **C. F. Guilbert.** (Écl. Électr. 17. pp. 301–310, 1898.)—This is a fully illustrated article on the various devices for the starting and regulation of direct current motors.

W. G. R.

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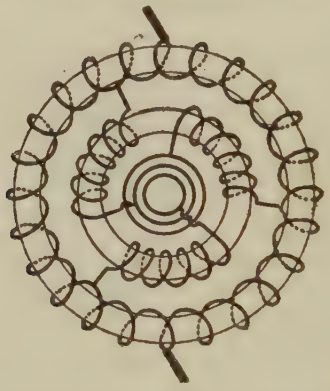
757. *Rotary Converters.* **S. P. Thompson.** (Instit. Elect. Engin. Journ. 27. pp. 651–689, 1898. Discussion, pp. 690–739.)—After a brief consideration of the various uses to which rotary converters may be put, the author considers the problem of the distribution of current in the armature of a converter. Dealing first with a single-phase converter, he determines the alternating current which would flow through the armature coil for different positions of the armature in the field if there were no continuous current simultaneously traversing the armature. By superposing this continuous current on the alternating one for any given position of the armature, the actual current distribution in the armature windings for that position is obtained. A complete set of diagrams is given which clearly exhibits the changes in the current distribution during a complete period. It appears that the converter armature is periodically accelerated and retarded, acting at a certain instant wholly as a motor, and at another wholly as a generator. The peculiar distribution of current in the windings produces unequal heating, the coils which are close to the slip-ring connectors being much more heated than those which lie midway along the periphery between the connectors. The total heating effect is somewhat greater than would occur in the armature if used as a continuous-current machine, but less than that corresponding to its use as an alternator; the ratios of the heating being as 1 : 1·366 : 2 in the three cases (for equal power). The single-phase converter is a much less satisfactory appliance than a polyphase one: it has considerable variations of armature reaction, a greater and less uniformly distributed heating, and requires more accurate setting of the brushes than polyphase converters; it is, further, not self-starting from the alternate-current side. The principle of superposition of instantaneous currents is next applied to determine the current distribution in two-phase and three-phase converters. The unequal distribution of heat is less in a three-

phase converter than in a single-phase, but is greater than in a two-phase converter; the coils subject to the greatest heating being in each case those in the immediate neighbourhood of the points of connection to the slip-rings. In the application of converters to charge accumulators from alternate current mains, some method is necessary of changing the voltage as between charge and discharge. The arrangement adopted by Ritter consists in using a small continuous-current dynamo which is connected in series with the continuous-current side of the converter, and which is either mounted on the same shaft or driven by a pulley from it. The P.D. is adjusted by varying the excitation of the auxiliary machine. The ratio of the E.M.F.s on the two sides of a converter is generally an awkward one in machines of ordinary construction. Two methods have been described for reducing this ratio to a more convenient number. One consists in altering the distribution of the magnetic flux by changing the width of the pole-pieces; the



other, due to Neldt, and illustrated in the accompanying diagram, is to include on the alternating-current side additional windings (mounted on the same core) between the slip-rings and the armature winding proper. The paper concludes with a description, accompanied by drawings to scale, of some recent types of converter.

In the discussion, the effect of an accidental short-circuit of some 15 seconds' duration on a large converter is described. The converter was driven from the two-phase side and was fairly heavily loaded; it was running in parallel with a turbine-driven exciter of but $\frac{1}{7}$th the capacity. The alternating E.M.F. sank to zero, and when the short-circuit was burnt out the E.M.F. rose slowly and reached its normal value, the converter being still in step, and delivering its proper share of exciting current. It is pointed out that two converters working in parallel on the three-phase side cannot be joined up to give a three-wire system on the continuous-current side. The "hunting" of converters is alluded to by almost every speaker. This action may in some cases become very

troublesome. The remedy is to be found in embedding heavy conductors in the laminated pole-pieces, the currents induced in these conductors tending to keep the armature rigidly in synchronism ; and in using engines with a very uniform angular velocity for driving the generating plant. Triple concentric cables have been found to introduce troublesome unbalancing of the voltage, and should preferably not be employed where rotary converters are to be used. A. H.

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758. *Rotary Converters.* **C. P. Steinmetz.** (Elect. World, 32. pp. 650–652, 1898.)—This is the first of a series of articles. The author calculates the following table on the assumption of a perfectly efficient machine :—

	Continuous Current.	Single Phase.	Three Phase.	Four Phase.	Six Phase.	Twelve Phase.	n Phase.
Volts between collector ring and neutral point.		$\frac{1}{2\sqrt{2}}$	$\frac{1}{2\sqrt{2}}$	$\frac{1}{2\sqrt{2}}$	$\frac{1}{2\sqrt{2}}$	$\frac{1}{2\sqrt{2}}$	$\frac{1}{2\sqrt{2}}$
Volts between adjacent collector rings.	1	$\frac{1}{\sqrt{2}}$	$\frac{\sqrt{3}}{2\sqrt{2}}$	$\frac{1}{2}$	$\frac{1}{2\sqrt{2}}$	0·183	$\frac{1}{\sqrt{2}\sin\frac{\pi}{n}}$
Amperes per line.	1	$\sqrt{2}$	$\frac{2\sqrt{2}}{3}$	$\frac{1}{\sqrt{2}}$	$\frac{\sqrt{2}}{3}$	0·236	$\frac{2\sqrt{2}}{n}$
Amperes between adjacent lines.	1	$\sqrt{2}$	$\frac{2\sqrt{2}}{3\sqrt{3}}$	$\frac{1}{2}$	$\frac{\sqrt{2}}{3}$	0·455	$\frac{\sqrt{2}}{n\sin\frac{\pi}{n}}$
Rating by mean armature heating.	1	0.85	1·34	1·64	1·96	2·24	

W. G. R.

POWER DISTRIBUTION, TRACTION, AND LIGHTING.

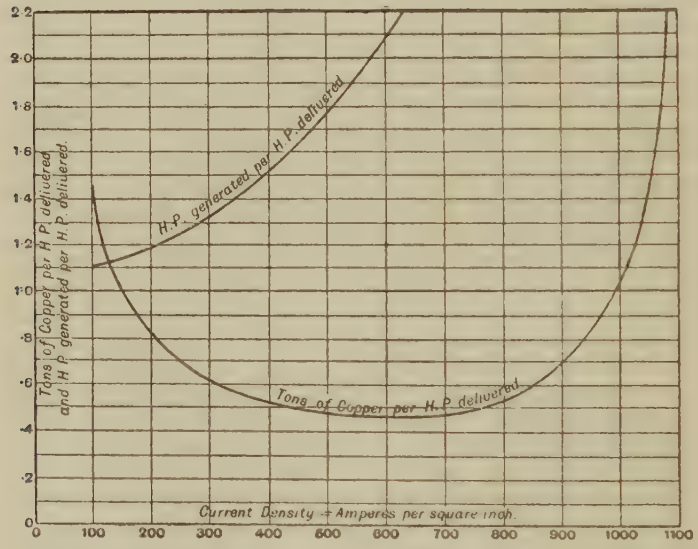
759. *Electricity on Board Ship.* **S. D. Greene.** (Amer. Instit. Elect. Engin. 16. pp. 21–35, 1899.)—The modern first-class battleship may require 1,000 I.H.P. for driving its auxiliaries at any one time, and the first-class cruiser 600 I.H.P. Power for these must be generated at a central point, and there can be used steam, hydraulics, compressed air, or electricity. Hydraulics and compressed air have a low efficiency of conversion (from steam) and it is difficult to prevent leaks, freezing, bursting, &c. With steam, the danger to life is considerable in action: men will face shot but not steam or hot water. Injurious heating of living quarters is almost inevitable with steam and exhaust-pipes. Electricity is more efficient than steam, and the motors are superior in simplicity and reliability. In the late war, two of the *Brooklyn's* turrets were controlled by steam motors and two by electric motors, and the officers report that the latter were far superior in ease of manipulation and fineness of control. A valuable paper, entitled "Steam Consumption of the Main and Auxiliary Machinery of the U.S.S. *Minneapolis*," by Engineer White, appeared in the Journ. Amer. Soc. Naval Engineers, Feb., 1898. This vessel is a first-class protected cruiser of about 7,500 tons displacement, and represents the highest type of her class. She has nearly forty steam auxiliaries. From White's observations during a seven days' run from Gibraltar to Philadelphia, the average steam-consumption of the main engines was 20·8 lb. per I.H.P. per hr., and of the auxiliaries, 119 lb. per I.H.P. per hr. These results are probably better than the average on most warships; under the most favourable conditions the auxiliaries probably consume at least 20 per cent. of the total coal and water used (or twice as large a proportion as in a modern central station). Assume 1,000 I.H.P. required at the motors in a vessel. A 250 volt or a three-wire system should be used in preference to the usual naval standard of 80 volts, which was fixed with a view to searchlights only. Assuming 82 per cent. efficiency for engine and generator, and 80 per cent. for line and motor, the overall efficiency between I.H.P. and B.H.P. at motors is 65·6 per cent. Thus 6–150 kw. sets, with one in reserve, would do, and the sets at work could be kept at full load, so that their steam consumption would be about 20 lb. per I.H.P. per hour, or about 30 lb. per B.H.P. hr. at motors. Allowing 25 per cent. margin for steam leakage, friction of gears, &c., we still have only 37·5 lb. per H.P. per hour as against the 119 lb. required in the *Minneapolis* tests, showing a saving of 70 per cent. With better compound engines, the average steam consumption on auxiliaries might be reduced to 75 lb. per H.P. per hour; but taking this figure, electric driving will show a saving of 10 to 20 per cent. in coal, corresponding to a proportionately greater steaming radius.

For a total maximum capacity of 2,000 H.P., the present weight of steam auxiliaries is about 100 tons. If electric drive is used, we must add 175 tons for the 7–150 kw. units, the weight of which is at present limited by the navy specifications to one-third of a pound per watt of rated capacity. Electric wiring will be lighter than steam piping, so that we may conclude that the electric plant will weigh from 2½ to 3 times the steam plant, but will save 10 to 20 per cent. in coal. In an Appendix an article is quoted from Cassier's Magazine, March, 1899, by G. W. Melville, confirming the large steam consumption in auxiliary machinery aboard warships, but pointing out that the extra weight and cost of electric motors prevent their use for forced-draught blowers and other little-used plant.

Discussion (pp. 36–56, 1899.). **H. Ward Leonard** described his method of control used on turrets. A motor and a generator, identical as regards voltage and output, but not necessarily as regards speed, have their armatures short-circuited on one another. The motor field is fully excited at all times, but the separately excited generator field is connected through a rheostat of large range and a reversing switch. The generator armature is driven always at full speed, and by varying its field any voltage from zero to the maximum in either direction can be readily obtained. With this arrangement there will be a definite speed for each position of the generator rheostat, and this speed will be practically independent of the torque of the motor; this is not the case when the motor is controlled by a rheostat. Not only acceleration but retardation are absolutely under control, the motor acting as a generator in the latter case; great smoothness is obtained, because the force causing acceleration or retardation is produced in such a manner that the energy is nearly proportional to the square of the velocity; the opposite is the case with a mechanical brake. No difficulty has been found with sparking at the generator. The *Brooklyn's* turrets have been started and stopped thirty-seven times in a minute: this fineness of control is the secret of pointing guns. **E. Thomson** has been experimenting on small, simple, non-condensing engines, on the same lines as M. Serpollet, and in a 4 H.P. engine can get 1 B.H.P. for 20 lb. of water per hour by imitating the gas-engine cycle. Dry or superheated steam at 160 to 200 lb. pressure is admitted behind piston by a poppet valve and exhausts through holes uncovered by the piston at the end of its stroke. The steam sweeps out all water, and what is left is driven back on dry hot surfaces. The engine has been operated with all degrees of superheat. The cut-off can be varied: two-thirds gives continuous torque. **J. W. Lieb, Jr.**, has seen German expert tests of 50 H.P. engines with Schmidt system of superheating showing less than 10 lb. steam consumption. **J. Bijur** finds that a drop of 25 volts between generator and searchlight arc is necessary for steady working: if the drop is increased to 110 volts, the regulating effect is too great and "hunting" results. E. H. C.-H.

760. *Long-Distance Power Transmission.* **G. Forbes.** (Soc. Arts Journ. 47. pp. 25–37, 1898.)—The gold-mining industry is particularly favourable to long-distance transmission, as it requires a continuous day and night supply of power, and the miner will frequently pay £70 to £100 per annum for the horse-power. Power may be economically transmitted 500 miles to the Rhodesian mines from the Victoria Falls. In the Coolgardie goldfields £180 per H.P.-year is offered, and the author has shown that it would pay to transmit power from steam engines at the coast, where coal and water are cheap, to a distance of 300 miles. Broadly speaking, the power required for rock breakers, stamps, &c., is such that 1 H.P. mills 1 ton of ore per day in hard quartz, the value of the gold being £3 or more

FIG. 1.



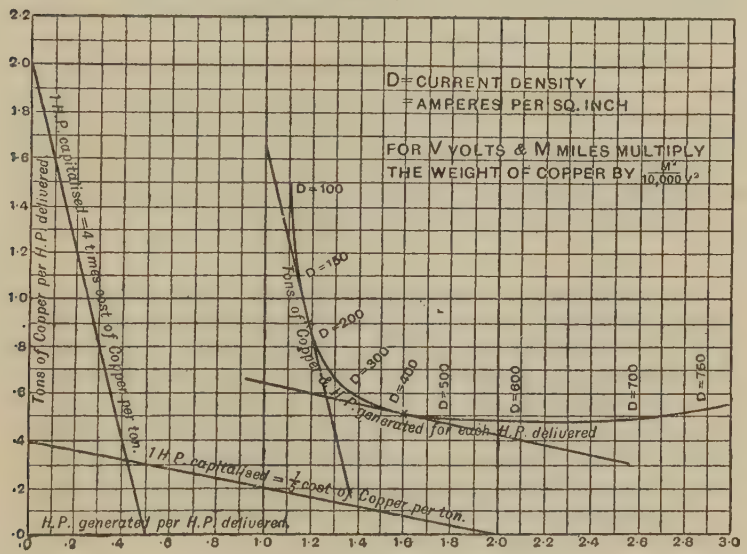
per ton. At the rate of 1 ton a day, £100 per H.P.-year is equivalent to only 5s. 5d. per ton of ore for milling expenses. Cairo could be more cheaply lighted by power generated at the First Cataract, 400 miles away, than by steam engines at Cairo. To minimise capital expense, the author proposes the division of capital account into two parts—ordinary speculative stock, and bonds on the copper, which he considers the soundest of investments. Four per cent. ought to cover the chances of a change in market value of the copper.

Rapid calculations for any special case of long-distance transmission may be made from curves or tables, based on current density, drop of volts and inefficiency (H.P. generated per H.P. delivered). If power cost nothing the cheapest arrangement would be an inefficiency of two (see Fig. 1). The curves and

tables are drawn for 10,000 volts continuous current, and only require correction for temperature and sag. They are equally applicable to single or two-phase transmission at 10,000 effective volts or at 5,000 effective volts from any wire to the middle of the electric system or to three-phase transmission at 5,000 volts from any wire to the middle of the electric system; but with alternating current, corrections must be made for self-induction and capacity.

Fig. 2 gives the inefficiency at each current density and the tons of copper per H.P. delivered at 100 miles, with 10,000 volts continuous current, in terms of the inefficiency. For any other volts V, and distance M miles, the multiplier for current

FIG. 2.



density is V/100M and the divisor for tons of copper per H.P. is $(V/100M)^2$. Divide the tons of copper per H.P. by 18 times the distance in miles and we get the sectional area in sq. ins. of the conductors (go and return) per H.P. Multiply this by the total H.P. to be delivered and we get the size of the conductors. Tables on which the curves are based follow. E. H. C.-H.

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761. *Polyphase Transmission of Power.* **F. Wallis.** (Electrician, 42. pp. 219–221, 1898.)—The author discusses the relative merits of the various systems. Thury advocates the use of continuous currents, and there are a number of power plants arranged on this plan. (See 1898, Abstract No. 874.) The continuous-current system is by far the most economical as regards copper in the line, the relative figures for continuous-current,

single-phase, two-phase (four-wire), and three-phase circuits being ·5 : 1 : 1 : ·75, assuming the same maximum P.D. in each case. The main disadvantages of the continuous-current system are the impossibility of using very large units (with the corresponding gain in efficiency and first cost) and the risk of accident to the attendants or machines. The single-phase alternating system is well adapted for long-distance transmission in cases where there is one receiving station with only one or two synchronous motors. Where a large number of smaller motors have to be supplied, a polyphase system is better, as it does away with the self-starting difficulty; further, it has the advantage of being peculiarly well adapted for use with rotary converters (with single-phase currents there is a difficulty in constructing rotary converters of much above 50 kilowatts output, on account of sparking at commutator). A. H.

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762. *New Stations of Brooklyn Edison Company.* (Elect. World, 32. pp. 579–584, 1898.)—An illustrated description, containing a number of details regarding the switchboard arrangements, &c., of the main generating station and two sub-stations recently constructed by the above Company. A. H.

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763. *Distribution by Alternating Currents.* **S. E. T. Ewing.** (Elect. Engin. 22. pp. 774–775, 817–818, 837–838, 1898.)—This paper describes and compares most of the systems of distribution in present use, and contains many useful hints as to the arrangement of transformer-pits and sub-stations so as to ensure ease of regulation and the safety of the men employed. For high tension mains the author advocates twin cables, composed of two separate conductors in one sheath, having a slow twist round each other, as combining the mechanical and electrical advantages of both concentric and separate conductors. M. G. W.

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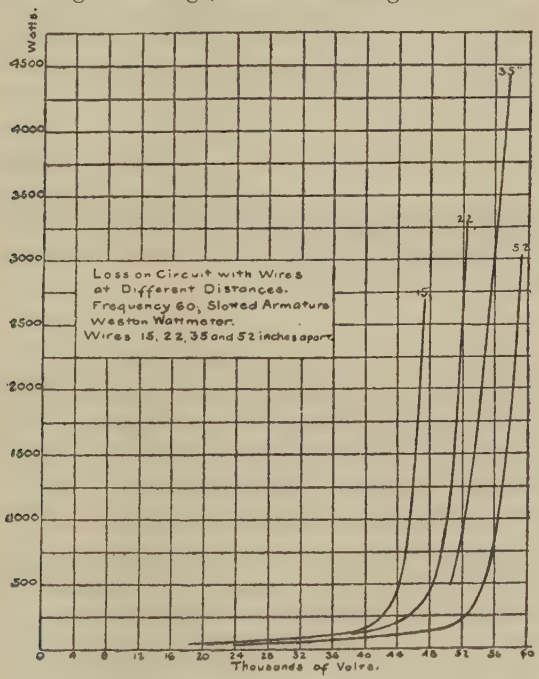
764. *High-Voltage Power Transmission.* **F. Scott.** (Amer. Instit. Elect. Engin. 15. pp. 673–718, 1898.)—This paper contains the results of some valuable experiments in high tension transmission. Some of the experiments were made in laboratories, but the greater number are tests made under actual conditions of working on an overhead line 2¼ miles long, at Telluride, Colorado, a continuous run of thirty-seven days at 50,000 volts being made to try the line. The voltage finally adopted for commercial transmission on this line was 40,000 volts.

The principal conclusions are as follows: The total loss is made up of loss over insulators and loss between wires, the former being comparatively negligible. The loss between wires depends on the diameter of the wires, the distance between them, and the wave form of the E.M.F., but the variations which may

occur under favourable commercial conditions locate the point of increase of loss at about 50,000 to 60,000 volts. The loss between wires is not affected by any atmospheric conditions except precipitation; this statement must of course be taken as applying to a climate similar to that in which the measurements were made. The lines were seldom in fog, and when they were so, or when rain was falling, the moisture was pure, the line being distant from any large town.

For a given transmission there is a certain economical voltage, since increasing the voltage, while decreasing the loss in the wires,



increases the loss between them. It is believed that the sine wave form is the best for this class of work.

Glass insulators have more points in their favour than porcelain. All breakdowns on poles occurred at cross-arms that had been strained and cracked by weather; the salts from the body and surface of the wood probably settle in these cracks, and the current follows the line of them.

The paper contains curves of all the results obtained, sketches of insulators, lightning arresters, &c., and a full description of all the apparatus used in the experiments.

One of the curves showing the loss between wires at different distances apart and with varying voltages is reproduced with this abstract. M. G. W.

765. *Carlisle Electric Supply Station.* (Electrician, 42. pp. 294–298, 1898.)—The system adopted at Carlisle is the three-wire system, with an earthed middle wire, and 460 volts between the outers. Steam-driven balancing dynamos are used and a battery. The boosters are arranged so that they can be used in series with the cells, and add to the voltage of the dynamo during charge, and to the voltage of the cells during discharge.

An exceptional feature in the plant is the provision made for utilising the dynamos either for the 460 volts lighting network or the contemplated 500 volts tramway system; for the former purpose they are used as shunt machines, for the latter a series winding is added, and they run compound.

The arcs used for public lighting are connected 10 in series across the 460 volt mains. M. G. W.

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766. *Power Transmission at Granada.* **R. B. Ritter.** (Ind. Élect. 7. pp. 401–405, 1898.)—This plant is designed for ten 340 H.P. turbines coupled direct to alternators. At present only two sets are installed. The power is transmitted $6\frac{1}{4}$ miles on overhead wires, at 4,200 volts. M. G. W.

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767. *Power Transmission at Hamilton, Ontario.* (Elect. World, 32. pp. 620–623, 1898.)—The power for this plant is derived by discharging a feeder of Lake Erie into Lake Ontario; the available head thus obtained is 260 feet. Reaction turbines of the inward flow radial type are used; each develops 1,950 H.P. at 400 revs. per min., and is coupled direct to a two-phase alternator.

The current is generated at from 2,000 to 2,400 volts, and transformed to about 24,000 volts for transmission along the thirty-five miles of overhead line to Hamilton.

The line consists of four bare copper wires placed 18 inches apart on poles, with a barbed wire lightning arrester.

It is interesting to note that no fuses have been placed on the generator switchboards, a short circuit being considered less dangerous than a sudden throwing off of load with turbine gates full open.

The article contains particulars of many ingenious mechanical arrangements, and is fullly illustrated. M. G. W.

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768. *McGurty High-Speed Mail System.* (Elect. Engin. N.Y. 26. p. 183, 1898.)—The system invented by McGurty is for the purpose of carrying mail, newspapers, and express matter at a high rate of speed, embodying devices to have the car stop at any desired station, and doing away with an attendant on the car.

The system involves the use of a new automatic controller and trolley, and also insulated sections and brake. The cars will be 30 feet in length, with a capacity of 40,000 lb., and will be designed to run at 120 miles per hour. The car is fitted with a new type of alternating current motor, one of which is mounted directly on the front, and one on the rear axle of the car. On board the car is an automatic rheostat for starting the car, there being no attendant. This rheostat embodies a mechanism by means of which the car can be started as slowly or rapidly as is desired, bringing it up to speed in one or two minutes, or even less. There is also provided an electric brake, which comes into operation as soon as the current is applied to it, and is released when the current is shut off. It can be so regulated by springs as to stop the car at a definite predetermined place, and any desired time after the current is applied or shut off. An automatic controller is also placed on the car, which reduces the speed when turning corners, or down grades, or when approaching stations.

Illustrations are given showing the arrangement of the track and car. L. J. S.

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769. *Chicago and Milwaukee Electric Railway.* (Elect. World, 32. p. 207, 1898.)—The above line may be called an inter-suburban railway. The plan which was adopted for power generation and distribution consists of a combination direct current and three-phase alternating current system, with a generating station placed at the centre of the line. The sections of the road adjacent to the power station are supplied with direct current from the power house itself. Sections of the line at a distance from the power house obtain their supply of current from sub-stations. The location of these sub-stations and their distance apart is governed by the conditions of traffic and somewhat by the nature of grades along the line. A map is given showing the disposition of the line and feeders. A novel feature is to be found in the electrical equipment of the power station. Two different types of generators are employed, one is an alternating three-phase generator, having a capacity of 250 kw. and working at 25 cycles per second. The current is generated at a potential of 5,500 volts, ready to be delivered directly to the transmission lines without the use of transformers. The second type of machine is a combination generator. It is also a 250 kw. machine, and can deliver its output either as a direct or as a three-phase current. The windings of the armature are connected on one side to a commutator and on the other side to collector rings. The potential of the direct current end is 600 volts, while the three-phase current is delivered at a pressure of 380. This machine can be used to supply current directly to the trolley passing in front of the power station, or can be used to operate

the motors in the sub-stations, or for both purposes, at the same time dividing the load in proportion to the demand.

When the three-phase current from this generator is transmitted to the sub-station the pressure is raised from 380 to 5,500 volts by means of transformers, which are cooled by a blast fan operated by a 1 H.P. induction motor. The sub-stations are arranged each to contain step-down transformers, a rotary converter, and a storage battery. The electrical equipment of the sub-stations is not in duplicate. This has been considered unnecessary, as it is intended to mount the machinery needed for a sub-station, viz., step-down transformers and one rotary converter, upon a truck fitted with motors. In case of breakdown at any sub-station, the battery can be relied on to supply current for several hours, during which time the portable reserve sub-station equipment can propel itself to the crippled station, and be connected ready to operate until the repairs have been made. L. J. S.

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770. *Bastille-Charenton Electric Tramway.* (Écl. Électr. 17. pp. 317–329, 1898.)—The greater part of this line is worked on the trolley system, but in some parts of the city the current is brought to the motors by an underground conduit. A point of novelty in connection with this line is the use of rails bonded by the Falk system, which is said to result in exceedingly smooth running. The cars employed are of a light construction, with a frequent service.

Apart from the ordinary generators at the power station, a battery of accumulators is employed, consisting of 250 cells with a capacity of 350 ampere hours. This battery is used not only for steadying the load of the generators, but also for supplying currents to the underground portion of the circuit, and for lighting purposes after the stopping of the traction service. The underground portion of the circuit consists of two insulated cables isolated from the remaining overhead portion of the circuit.

Details of the installation are given *in extenso*. L. J. S.

SCIENCE ABSTRACTS.

PHYSICS AND ELECTRICAL ENGINEERING.

JUNE 1899.

GENERAL PHYSICS.

771. *Flexibility of Marble Slabs.* **P. Gamba.** (N. Cimento, 9. pp. 117–130, 1899.)—The deformations of dry slabs of marble, under the action of certain loads, are determined (see Abstract 641, 1899). They are then soaked for forty-eight hours in various liquids, and their deformations under the same loads again determined. In general the soaking increases the deformation. Of the liquids tested, glycerine has the greatest effect; then follow oil, water, and paraffin dissolved in petroleum. The effect of petroleum alone is negligible. A. Gs.

772. *Mechanical Properties of Copper.* **M. Rudeloff.** (Mitt. Königl. techn. Versuchsanstalten, Berlin, 16. pp. 171–219, 1898.) —Eleven plates or bars of copper containing from 97·3 to nearly 100 per cent. of copper (tin and zinc being the chief impurities) are submitted to an elaborate series of experiments on extension, with loads up to the breaking load at temperatures varying from -80° to 600° C. The numerical results are fully given in tables and curves. The general conclusions reached are:—

Mechanical treatment (hard drawing, rolling, or hammering) increases the strength, especially the stress at the limit of ductility, diminishing at the same time the extension of length at the fracture considerably, and producing, with the more impure samples, proportionality between extension and stress. The strength diminishes steadily as the temperature rises, but the diminution is considerably less up to 200° or 300° than at higher temperatures. The stretching with equal loads, within the limit of ductility, increases as the temperature rises; for some samples, however, this increase is only marked with higher loads. The extension of length at the fracture is increased by cooling to -20°; between

+20° and 300° it is nearly constant, whilst at higher temperatures it usually decreases with metal previously heated to redness and increases with the hammered or rolled material. The increased strength produced by mechanical treatment is retained almost unimpaired up to 200° to 300°, but at higher temperatures is gradually lost; at about 500° the hard and soft metals behave in nearly the same way. The proportionality between stress and extension produced by mechanical treatment disappears at from 200° to 300° C. The strength of the less pure specimens is on the whole increased more by mechanical treatment than that of the purer sorts, and the former retain their elasticity at higher temperatures. Hard rolling and hammering in the cold produce the same effects. T. E.

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773. *Thermodynamic Equivalence in a Bimetallic Conductor.* **P. Straneo.** (Roma, R. Accad. Lincei, Atti, 8. pp. 196–202, 1899.)—Mathematical investigation of the conditions under a periodically reversed current through a bimetallic junction.

A. D.

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774. *Range of Molecular Forces.* **W. Mueller-Erzbach.** (Wied. Annalen. 67. 4. pp. 899–900, 1899.)—The author attempted to determine more accurately the thickness of the separating layer through which solid bodies are capable of exerting an attractive force upon the molecules of a gas. Rectangular glass plates 6 cm. long and 2 cm. wide were covered with a layer of sealing-wax or beeswax. They were then painted with a solution of gum in glycerine, about ten times in succession, each deposit being allowed to dry in until it was quite smooth. The strips were then put into test-tubes and introduced into vessels containing evaporating carbon bisulphide, but arranged in such a manner that the liquid bisulphide was always 1 or 2 degrees colder than the test-tubes. Some twelve or eighteen hours later the test-tubes contained some liquid CS_2, and drops of the same substance adhered to the covering layer—and that in spite of the higher temperature of the test-tubes. The thicker the layer of gum the feebler was the effect of the carbon bisulphide, until at last the test-tube, with its contents, showed no increase in weight. The thickness of the layers was determined by their weight. In the case of sealing-wax, covered with gum to a depth of 0·35 mm., no increase of weight was observed even after a fortnight's exposure. Under the same circumstances beeswax was protected by a layer only 0·14 mm. thick, whereas on sealing-wax the CS_2 penetrates a layer 0·16 mm. thick with ease. The slightest gap in the covering was at once indicated by a considerable increase of weight. With a degree of moisture of the air amounting to 72 per cent., thin gum layers over wax were so elastic that in many places solutions were formed under them, producing bulging of the layers. These solu-

tions partially evaporated in the open air, and were formed again on exposure to carbon bisulphide vapour. The covering remains, however, continuous, and does not tear unless the quantity of CS_2 absorbed is excessive.

Tissue paper soaked in gum has a protective action similar to that of pure gum, but much thinner coverings suffice. The same remark applies to collodion, but in using collodion care must be taken that it is in intimate contact with the glass. It is best mounted on a substratum of gum. Two films of collodion, with total thickness of 0·055 mm., together with a film of gum 0·056 mm. thick, formed an amply sufficient protection against solution by carbon bisulphide. It appears therefore that the transition to a second medium materially reduces the molecular motion. E. E. F.

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775. *Viscosity of Gases.* **P. Breitenbach.** (Wied. Annalen, 67. 4. pp. 803–827, 1899.)—The author uses the transpiration method, and an apparatus similar to that devised by E. Wiedemann. The gases examined include air, ethylene, carbonic acid, methyl chloride, and hydrogen. The following are the values of $\eta \times 10^7$ at 15° C.: Air 1809, ethylene 1011, CO_2 1464, methyl chloride 1057, hydrogen 893. The viscosity increases in proportion to a power of the absolute temperature whose index in the various gases lies between 0·6 and 1. It is therefore to be supposed that the sphere of influence of a molecule decreases as the temperature increases. For one and the same gas the index mentioned is not constant, but decreases with increasing temperature; even at low temperatures a decrease is observed. In mixtures of gases the viscosity does not change in proportion to the constituents, and Puluj's formula is only approximately correct. At higher temperatures the transpiration method gives results different from those of the method of oscillation, but the explanation based upon a supposed greater sliding of the gases along the wall of the tube at the higher temperatures does not appear to hold good. E. E. F.

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776. *Rate of Explosion in Gases.* **D. L. Chapman.** (Phil. Mag. 47. pp. 90–104, 1899.)—In this paper formulæ are given which express the maximum rates of explosion in gases and the maximum pressure in the explosive wave. The data used are mostly taken from the Bakerian Lecture of 1893 by Dixon, on the "Rates of Explosion in Gases." It has been established that the maximum velocity of explosion, in a mixture of definite composition and at a fixed temperature and pressure, has a definite value, independent of the diameter of the tube when that diameter exceeds a certain limit. Increase of temperature causes a fall in the velocity of explosion, whereas an increase of pressure has the reverse effect up to a certain limit, beyond which the

velocity remains constant. Dixon has also shown that an explosion is in its character essentially similar to a sound-wave.

The present paper is mathematical in character and the formulæ deduced, partly from experimental results, partly from assumptions not yet experimentally confirmed, are used to calculate the rates of explosion in various explosive mixtures. These calculated values are given in tables. J. J. S.

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777. *Directive Action of one Crystal on another.* **J. H. Poynting** and **P. L. Gray.** (Roy. Soc. Proc. 64. pp. 121–122, 1898.)—Experiments were carried out in search of a directive action of one quartz crystal on another. Two quartz spheres were used, one 0·9 cm. in diameter, the other of 6·6 cm. diameter. The larger was rotated continuously near the smaller in a period of 115 seconds in one series, and in a period of 230 seconds in another series of observations. Any directive action should manifest itself as a periodic couple, producing forced oscillations in the smaller sphere. The results obtained were negative.

J. J. S.

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778. *Velocity of Solidification.* **H. A. Wilson.** (Cambridge Phil. Soc. Proc. 10. pp. 25–35, 1898.)—A mathematical discussion of the relation between the velocity with which rays of solid grow in a super-cooled liquid when solidification is once started in it, and the amount of super-cooling. The rate at which solidification takes place depends upon the difference between the internal pressure in the solid and that in the liquid—a difference which in the case of water and ice at $-1°$ C. amounts to 12 atmospheres. The investigation gives results parallel, for unconstrained material, to the lowering of the melting-point of ice, under pressure. If A is the force required to give unit velocity to one gramme of the liquid diffusing through itself, F the latent heat of fusion, a the thickness of a layer of molecules acted upon at the surface of separation (these being driven into the solid from the liquid), and $(\theta_0 - \theta)$ the super-cooling, then ω, the velocity of solidification is—

$$\omega = \frac{F}{Aa} \cdot \frac{\theta_0 - \theta}{\theta_0}$$

Since A increases rapidly as the temperature falls, ω attains a maximum, say at temperature θ_1. If the super-cooling be less than $\theta_0 - \theta_1$, the solidifying tip becomes warm, which retards the solidification; if it be greater the tip remains at θ_1, and the velocity of solidification is constant. Phenomena analogous to explosion occur when at very low temperatures the solidification is retarded by viscosity and then the supercooling is gradually diminished.

A.D.

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779. *Limitations of the Present Solution of the Tidal Problem.* **J. F. Hayford.** (Science, 8. pp. 810–814, 1898.)—The theory of the tides furnishes the periods, not the actual times of the occurrences of the tides, *i.e.*, the epochs of the components, not their range. The author explains the nature of the problems by first assuming that the earth is a rigid nucleus, covered by a uniform depth of water, and that the moon always presents the same face to it. Coming nearer to the actual conditions, he finds that if the earth were covered with water up to the top of Mount Everest—that is, to a maximum depth of ten miles—the mathematical solution, so far possible, would be almost intractable. The apparent rate of progress of the moon over the earth's surface is seventeen miles per minute; the tidal wave would be able to follow the moon if the ocean had a depth of thirteen miles. For depths varying between ten and five miles, the rate of progress of the tidal wave would vary between ten and one mile. The moon would tend to break down the old wave, and to build up a new one in advance of it. The actual conditions add to these difficulties a maximum sea depth of about five miles and reflections from exceedingly irregular shores. The real tidal wave moves northward in the Atlantic and part of the Pacific, and has an eastward tendency in at least two large areas, north of Europe and west of South America. In the Atlantic the semi-diurnal components are large as compared to the diurnal components; in parts of the Pacific they are small, so that the two tides of one day are of very different heights, and so that only one tide per day may result. At Batavia, *e.g.*, the component which has one high water per sidereal day is six times as large as the component having two high waters per lunar day. The conflicts with shores and bottom leave only the periods unaffected, the amplitudes are greatly changed. The effects of boundaries, bottom and sides, can best be studied in bays receiving tributaries of known depths, such as Chesapeake Bay, where complete data are obtained at Old Point Comfort, Baltimore, and Washington, and where observations are taken at forty-nine points on the bay, twenty-one along the Potomac, and sixty-one along other tributaries of the bay. The author suggests a graphic, rather than an analytic, study of this comparatively unworked field of the problem as most promising for extending our knowledge of the tides. H. B.

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780. *Gravity Determinations.* **K. R. Koch.** (Zeitschr Instrumentenk. 18. pp. 293–300, 1898.)—The author is going to carry out some determinations of the relative values of gravity in the kingdom of Wurtemberg. 1. He describes a support for a pendulum, devised by himself, which is practically free from sympathetic vibrations. 2. He gives details of comparisons between a standard clock and a chronometer with an arrangement for an electrical contact; also between a standard clock,

and a clock, without compensation, beating half-seconds. The tests prove the auxiliary instruments to be unsatisfactory. 3. He describes the apparatus he intends to use. In the central station there will be a Hipp's clock, provided with a Riefler's pendulum. This pendulum has an electrical contact, and will be put in communication with the field-station by means of relays, experiments proving that their time-lag is practically constant. Thus the Riefler's pendulum can be compared with the movable one. Riefler's pendulum itself will be compared systematically with a standard clock. 4. Some experiments are performed which prove that if a pendulum has been lying in its case for some time its time of vibration increases with use, probably due to a gradual stretching by its own weight. Further experiments are in progress. A. Gs.

781. *Periodicity and Velocity of Earthquakes.* **A. Cancani.** (Roma, R. Accad. Lincei, Atti, 8. pp. 76–79, 1899.)—The paper has reference to the earthquakes which have occurred for centuries in the neighbourhood of the Marches and Roumania. The periodicity of the most violent disturbances is 100 ± 14 years. There are additional earthquakes with a periodicity of 23 ± 10 years. The velocity of the shock which occurred on the 21st of September, 1897, was 0·86 kilometre per second to Florence, a distance of 165 kilometres from the epicentre; it was 1·46 per second to Rome at a distance of 240; and 3·62 per second to Utrecht a distance of 1,050 from the epicentre. A. Gs.

782. *Temperatures on Mountain-tops.* **J. Hann.** (Wien Akad. Sitzber. 107. pp. 537–568, 1898.)—The author compares the temperature curves registered at the observatory on the summit of the Sonnblick (3106 m.), and at the "Hannwarte" on the Obir (2140 m.). At the latter, the mean daily amplitudes are small. They amount to 0·9° in winter, 2·5° in spring, 3·8° in summer, and 1·6° in autumn. In November and December a very peculiar phenomenon is observed. There is the usual maximum at 2 p.m., but a secondary maximum is observed at 4 a.m., which at other seasons records the minimum. This maximum is due to the strong descending currents of air which prevail at that season, and which bring warmer currents to the mountain-tops. This phenomenon is not observed on the Sonnblick, on account of its greater height. E. E. F.

LIGHT.

783. *Reflection and Refraction of Light.* **Lord Kelvin.** (Phil. Mag. 47. pp. 179–190, 1899.)—Lord Kelvin discusses the subject for waves of compression-rarefaction as well as distortion at a plane interface between two isotropic elastic media. The general treatment is on the same foundation as his paper in Phil. Mag., 1888, pp. 414–425, but somewhat simplified. Assuming the velocity of the compression wave to be very small compared with that of the distortion wave, he obtains an expression for the ratio of the amplitudes of the incident and reflected distortional waves, which yields Fresnel's sine law if the densities of the two media are equal, and Fresnel's tangent law if the rigidities are equal. He also discusses shortly the case of the imaginary wave in total reflection. S. H. B.

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784. *Extension of Maxwell's Theory.* **E. Edser.** (Roy. Soc. Proc. 63. pp. 374–389, 1898.)—A dielectric, like an electrolyte, is assumed to consist of molecules, each comprising, in the simplest case, two oppositely charged atoms at a definite distance apart. In a homogeneous medium, when not subjected to electric strain, these molecules will be arranged in such a manner that any element of volume will possess no resultant electric moment. If a definite potential difference be maintained between any two parallel planes in the medium, the positively charged atoms will move to points of lower, and the negatively charged atoms to points of higher, potential. Thus two kinds of molecular strain are produced: firstly, a molecular rotation; and secondly, a separation in the molecule of the constituent atoms. Some observations are added on the resultant field acting on a polarised molecule in a dielectric subjected to strains such as those considered. Subsidiary equations for the atomic vibrations (rotational separational) are given, and the refractive index is finally determined in the form

$$\mu^2 = \mu_\infty^2 + \frac{c'\lambda_1^2}{\lambda^2 - \lambda_1^2} + \frac{c''\lambda_2^2}{\lambda^2 - \lambda_2^2},$$

which is a general form of Ketteler's dispersion formula.

Double refraction, in the case of a uniaxal crystal, is explained on the assumption that the molecules are arranged with their axes parallel to a certain direction. Electrical disturbances perpendicular to this direction will produce a molecular rotation, whilst those parallel to this direction will produce an inter-atomic separation. The doubly refracting nature of a dielectric when subjected to electric strain is thus explained. For infinitely quick vibrations the refractive index of the above medium will be

equal to unity—a result possibly explaining the action of material bodies on Röntgen radiations. From the equations obtained it is further shown that the coefficient of absorption of a feebly absorbing substance or mixture is proportional to the number of absorbing molecules per unit volume. E. E. F.

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785. *Colour of Iodine Vapour.* **J. Dewar.** (Cambridge Phil. Soc. Proc. 10. pp. 44–47, 1898.)—Pure iodine in the solid state is usually represented as being perfectly opaque to light, but this is not the character of the iodine distilled and condensed on a surface of glass at temperatures between $-182°$ and $-183°$ C. in vacuum test-tubes or bulbs by the use of liquid air. Under such conditions it is easy to get transparent films of iodine of varying grades of thickness showing brilliantly the colours of thin plates by reflection; and to keep them permanently as long as the low temperature is maintained. The first addition of liquid air to the vacuum bulb or test-tube containing excess of solid iodine causes instant precipitation of an opaque film, but this can be avoided by cooling the crystals of iodine which have been sublimed on to the lower part of the outer test-tube or bulb by a preliminary cooling with solid carbonic acid. The iodine is thus deposited from an atmosphere of great tenuity. Now J. J. Thomson has shown that the effect of the pressure of an inert gas must be to raise the vapour pressure above that given in a vacuum. Taking his formula as being applicable to iodine, the difference between the two conditions of pressure should amount to $\frac{1}{440}$ of the whole. The question remains as to whether this amount is sufficient to explain the difference of colour, or whether it is necessary to bring in other factors, such as the solution of solids in gas under compression, or dissociation. So much is certain, that one atmosphere of pressure is sufficient to produce a sensible difference of colour in iodine vapour diffused in air as compared with a vacuum. E. E. F.

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786. *Objectives of Small Aperture.* **H. Harting.** (Zeitschr. Instrumentenk. 18. pp. 331–335, 1898.)—A collection of formulæ for three radii of a cemented bipartite objective, calculated from the glass, the working distance and the length of tube; applicable to water immersion as well as to several dry systems. The formulæ are developed in full in Sitzber. d. K. Acad. d. Wiss., Wien, Math.-naturw. Kl., 107, IIa, p. 624. The objects in view are, with two lenses cemented together (of glass selected in accordance with the results of calculation), to provide a given focal length or else a given working distance, to achromatise for two parts of the spectrum, to eliminate spherical aberration for one colour, and to do the same for slightly non-axial rays. A. D.

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787. *Compound Objectives.* **H. Harting.** (Zeitschr. Instrumentenk. 18. pp. 357–380, 1898.)—With the older kinds of crown and flint glass two object lenses could not be so cemented together that besides achromatism and correction of spherical aberration the sine rule should be rigidly observed. In all pairs of lenses which could be combined from the older crown and flint glasses, the dispersion of the crown was too high and that of the flint too low in comparison with the refractive index. Hence the objectives so made up always showed spherical aberration outside the axis after it was eliminated within the axis. The new glasses produced at Jena provide a nearly perfect solution of the problems referred to in two ways. The first is a combination of a borosilicate crown of low refractive index (say 1·50) and comparatively small dispersion with a lead-silicate flint of relatively high refractivity (say 1·64). The second is a combination of a barium-silicate crown of high refractivity (1·58) with a flint whose refractivity need only be very slightly higher (0·01). This latter combination also offers the advantage of smaller external curvatures, and consequently greater apertures for the same spherical aberration. The problem of a perfect objective is thus within measurable distance of a final solution. E. E. F.

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788. *Recent Views on Colour.* **A. H. Abbott.** (Canad. Instit. Proc., Parts 1, 4, and 5. pp. 107–108, 1898.)—A summary of recent views as to the nature of colour, looked at from the psychological point of view. J. B. H.

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789. *Photometric Standards.* **F. Laporte.** (Elettricità, Milan, 17. pp. 755–759, and pp. 775–778, 1898).—Incandescent lamps standardised at the Physical Technical Institute, Charlottenburg, were examined at the Central Laboratory of Electricity, Paris. On the assumption that one Hefner unit is equal to 1·02 decimal candle or 0·051 Violle platinum unit, the comparative data were :—

Volts.	Amperes.	P. T. Institute.	Central Laboratory.	
		Hefners (obs.)	Decimal candles.	Hefners (calc.)
108·5	0·338	10	8·7	8·5
111·5	0·489	16	14·2	13·9

This led to a full comparative series of experiments. It was found incidentally that unless the ventilation of the photometer

room is very good, the Carcel lamp becomes sluggish and the fall off in lighting power is greater than the fall off in consumption of oil: so that in a room of 82·6 cub. metres, without ventilation, in two hours the consumption falls by 4 and the lighting power by 12 per cent. Under proper conditions the Carcel was found equal to the Bengel burner, consuming 105 litres of Paris gas per hour. In the Hefner lamp (Liebenthal) the variations due to height of flame are on the average: 38 mm., 0·941; 39 mm. 0·971; 40 mm. 1·000; 41 mm., 1·027; 42 mm., 1·054; and if x be the number of litres of water and vapour in a cubic metre of the air, the lighting power is $1{\cdot}049\ (1-0{\cdot}0055x)$, so that the standard power corresponds to a humidity of about 8·8 litres water-vapour per cubic metre. Carbonic acid, y lit. per cub. m., gives lighting power $(1{\cdot}012-0{\cdot}0072y)$. Defect of oxygen in the air lowers the power about 2 per cent. per litre of defect per cubic metre. The following table shows the results of the experiments:—

	Decimal candle.	Carcel lamp.	Hefner lamp.	German standard paraffin candle.
Decimal candle ...	1·000	0·104	1·13	0·955
Carcel lamp.....	9·600	1·000	10·90	9·200
Hefner lamp	0·885	0·092	1·00	0·815
German standard paraffin candle...	1·050	0·109	1·23	1·000

These results differ considerably from the datum 1 Hefner = 0·120 to 0·126 Carcel, obtained with the earlier but more variable models of the Hefner lamp. A. D.

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790. *Multiple Images in the Normal Eye.* **S. Bidwell.** (Roy. Soc. Proc. 64. pp. 241–245, 1899.)—A description is given of experiments on vision in which a luminous object, *e.g.*, the bright filament of an incandescent lamp is looked at through a lens, concave or convex, say of about 15 cm. focal length from a distance of a few feet. The roughly oval patch of luminosity formed upon the retina appeared to be made up of a crowd of separate images of the filament, some being brighter than others. The number of these images increased as the distance of the observer from the lamp increased, or when the lens was placed farther away from the eye. By sufficiently increasing the distance between the source of light and the eye as many as twenty-five images of the source (or thereabouts) might be made to appear in a row. The number of images thus seen varies with the dilatation of the pupil. There are indications that the original images may

be resolved into still simpler elements, giving 400 or 500 as the total number of elements produced by one source. These latter observations seem to indicate some fairly regular anatomical structure in or near the crystalline lens, and composed of cells measuring about 0·01 mm. in length or breadth. Possibly the cause may be found in the endothelium on the anterior surface of the lens, the cells of which are about 0·02 mm. in diameter. There is more difficulty in accounting for the formation of the images numbering twenty-five in a row, as no structure sufficiently coarse-grained to account for them (a network with meshes 0·2 mm. in length would be required) occurs in the eye. The author considers the effect may be a composite or differential one. J. J. S.

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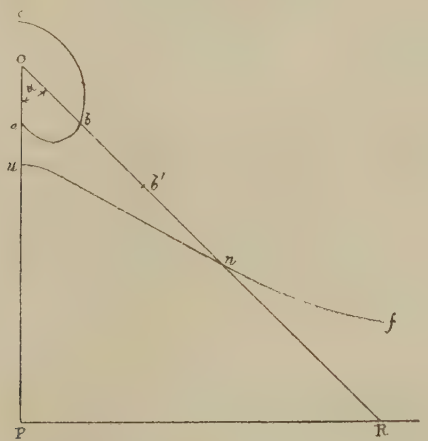
791. *Graphical Method of Determining Illumination.* **L. Hoest.** (Bull. Ass. Ing. El. Liège, 9. pp. 464–470, 1898.)—When it is required to find the illumination at every point of a horizontal plane due to a luminous source whose intensity in every direction is known, the following graphical method affords a rapid means of solution. The well-known formula $Ih^2/\cos^3 a$ gives the illumination at a point R of a horizontal surface due to a source whose height above it is h, and whose intensity in the direction of the point is I, a denoting the angle made with the vertical by the line joining R to the source. By putting $Ih^2/\cos^3 a$ = constant, and tracing the corresponding curve $u\,n\,f$



(see fig.), whose radius vector $On = I$ gives the luminous intensity of an *ideal* source which produces uniform illumination over a horizontal plane, we obtain a standard curve which is extremely useful for the rapid determination of the illumination due to any other source, such as the one whose luminous characteristic is represented by $a\,b\,c$ in the figure. For if

$V = Oa/h^2$ stand for the illumination at P due to the given source, and if we lay off Ob' so that $\frac{Ob'}{On} = \frac{Oa}{Ou}$, then we have

$$\text{illumination at R} = V\frac{Ob}{Ob'} = V\frac{Ob}{On}\cdot\frac{On}{Ob'} = V\frac{Ou}{Oa}\cdot\frac{Ob}{On} = \frac{Ob}{On}K,$$

where $K = V\frac{Ou}{Oa}$ is a constant. Hence the horizontal illumination at any point is at once determined by multiplying K by the ratio Ob/On corresponding to the point considered. A. H.

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792. *Radiation in a Magnetic Field.* **D. Macaluso** and **O. M. Corbino.** (Roma, R. Accad. Lincei, Atti, 8. pp. 38–41, 1899.)—At each side of an absorption line the light not only has its plane of polarisation rotated, but the plane-polarised light becomes elliptically polarised, this latter effect rapidly dying out as we pass away from the centre. A. D.

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793. *Zeeman Phenomenon.* **O. M. Corbino.** (Roma, R. Accad. Lincei, Atti, 8. pp. 171–175, 1899.)—Comes with Righi to the conclusion (see 1899, Abstracts, No. 423) that experiments with shifting beat-fringes are impossible with the light from Zeeman's tubes; for though, analytically, Righi's difficulties could be got over, the source of light cannot be made unique but is the resultant of independent vibrations of an infinite number of particles. A. D.

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794. *Lighting of Polarisation Apparatus and Saccharimeter.* **F. F. Martens.** (Zeitschr. Instrumentenk. 18. pp. 335–337, 1898.)—Apparatus described in which Lippich's method of using an illuminating lens in front of the nicols is employed, the focal length being such as to throw the image of the source of light into the neighbourhood of the analyser diaphragm. Adaptations to incandescent mantles and to a straight-filament electric glow-lamp. A. D.

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795. *Quartz-Spectrographs and Subsidiary Apparatus.* **C. Leiss.** (Zeitschr. Instrumentenk. 18. pp. 325–331, 1898.)—Descriptions of apparatus made by Fuess, of Steglitz, near Berlin: Schumann's quartz spectrograph, large and small model, his simplified quartz condenser, his sparking apparatus, and his universal sparking apparatus. Photo process reproductions of the spectrographic results obtained with commercial glass plates, up to the aluminium line 1852 in the ultra-violet are given. A. D.

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796. *Scale of Kirchhoff's Solar Spectrum.* **J. Hartmann.** (Berlin Akad. Sitzber. 46. pp. 742–756, 1898.)—The reduction of Kirchhoff's measurements to a scale of wave-lengths in absolute measure is difficult on account of the fact that his apparatus was differently adjusted for the different parts of the spectrum measured. Between D and F the scale drawn by Kirchhoff is too great, while in the outer portions it is too small. The difference is so great that between B and D the spectrum would have to be half as large again to correspond to the central scale. The author determines formulæ for the reduction of Kirchhoff's arbitrary scale to absolute wave-lengths, and tests the values given by the formulæ by comparing them with Rowland's photographic map of the solar spectrum. He finds that Kirchhoff's spectrum has to be divided into five portions, and different formulæ apply to the various portions. The first portion extends from A to D, the second from D to E, the third to 497 mm., the fourth to 471 mm., and the fifth is the rest of the visible spectrum. The reducing formula for the fourth portion, which deviates the most, is :—

$$\lambda = 891{\cdot}04 \text{ mm.} - \frac{6{\cdot}290971}{6904{\cdot}6 - K}$$

where K is Kirchhoff's scale-reading.

Apart from the faults of scale, the observations of Kirchhoff are of the most admirable precision. The probable error of a wave-length determination from the new formulæ is only about half an Ångström unit. E. E. F.

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797. *Electric Currents Induced by Röntgen Rays.* **A. Winkelmann.** (Wied. Annalen, 66. 1. pp. 1–28, 1898.)—This paper deals with the difference of potential induced between two plates of different metals when Röntgen rays are caused to traverse the space between them, and also with the electric current which passes when the two plates are connected by a wire.

Plates of copper, zinc and aluminium are experimented with, the Röntgen rays successively traversing the two plates normally, the distance between the plates and the distances of both from the source of rays being varied in different experiments. Several different methods of experimenting are adopted. In one a condenser is charged from one of the plates, the other being connected to earth, and the charge on the condenser after one, two, or several minutes' action is measured by a ballistic galvanometer. In a second, the current to earth from one plate is measured by a galvanometer, the other plate being also connected to earth. The difference of potential between the plates is measured by an electrometer. In a third method the electrometer is used also as the current measurer with the aid of a known resistance.

The results are all in accordance with the theory that the air

between the plates is *ionised*, and that almost immediately after the rays start a constant electromotive force exists between the plates analogous to the contact-difference of potential. The results of the time experiments with the condenser, when calculated theoretically on this assumption two experiments being included to give the constants, are in close agreement with the experimental results.

The currents measured are of the order of $6{\cdot}7 \times 10^{-9}$ amp. The resistance of the air between the metal plates is calculated from the current and the difference of potential, and from it the lower limit to the number of dissociated molecules per c.c. of air is found to be $4{\cdot}6 \times 10^{-13}$. J. B. H.

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798. *Gases Subjected to Röntgen Radiation.* **J. Zeleny.** (Cambridge Phil. Soc. Proc. 10. pp. 14–25, 1898.)—The passage of electricity through a gas under the influence of Röntgen rays is accompanied by movements of the gas itself, which are of considerable magnitude and can be rendered visible by NH_4Cl fumes, streams of which crossing the direction of conduction are deflected or bodily carried each to its neighbouring plate. For a given intensity of the rays the rate of the motion is dependent upon the potential gradient between the plates. In the absence of the Röntgen rays the motion of the fumes is not affected by the electric field. Streams of carbonic acid gas show similar results. The gas is dragged by the moving ions; equally in both directions if there be no free charge; more in one direction than the other if there be a free charge, *i.e.*, if the ions of one kind be more numerous. With limited plates the excess of pressure at their surfaces is relieved sideways, so that convection currents are set up, ultimately assuming a steady state. Measuring potentials extremely near to the plates, it appears that in the first tenth of a millimetre the fall of potential is about equal to what it is in the next three-tenths. The electric force acting upon the electrodes is increased by exposing the gas to Röntgen rays.

A. D.

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799. *Stereoscopic Radiography.* **V. Chabaud.** (Séances Soc. Franç. Phys. 3. pp. 154–164, 1898.)—The author describes an apparatus by which a foreign intrusion can be found in the human body, its place determined, and its distance from a given point of the skeleton found. It enables the operator in a few minutes to take two radiographs, to develop them, and examine them in a special stereoscopic apparatus and to draw conclusions therefrom. This result is achieved by the use of a vacuum tube which gives very rapid records, and a stand which enables the operator to take two radiographs of the same object from two different but precisely defined foci. E. E. F.

HEAT.

800. *Coefficient of Expansion of Air.* **W. Hoffmann.** (Wied. Annalen, 66. 2. pp. 224–236, 1898.)—The first part of this paper contains an experimental determination of the pressure-temperature coefficient of air at constant volume, and the second part an experimental comparison of this coefficient with the volume-temperature coefficient at constant pressure.

In the first investigation a constant volume air thermometer is used, in which the influence of variations in the atmospheric pressure is eliminated by having the pressure column of mercury in a long tube exhausted and closed at the top, thus forming a barometer. The experiment is performed in the usual way between two fixed points of temperature. The results of three experiments are :—

1. $\alpha_p = 0{\cdot}00367064$
2. $\alpha_p = 0{\cdot}00366897$
3. $\alpha_p = 0{\cdot}00366911$

Mean $\alpha_p = 9{\cdot}00366957$

The comparison of the two coefficients is carried out by means of a modified constant volume air thermometer, which can be used also as a constant pressure thermometer. An extra bulb is blown on the vertical capillary tube above the mercury index tube. This bulb is also provided with an index at its upper end. The volume of this bulb is made such that if the apparatus be used as a constant pressure air thermometer, this subsidiary bulb being kept in ice, the two fixed points of the thermometer are the two index marks, the zero being that at the top of the bulb and 100° being the one in the mercury tube. This condition is only approximately fulfilled, corrections being made from accurate measurements of the pressures.

The results of some preliminary experiments give the mean value—

$$\alpha_v - \alpha_p = 0{\cdot}00000123.$$

J. B. H.

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801. *Pressure and Temperature of Fusion.* **Demerliac.** (Journ. de Physique, 7. pp. 591–598, 1898.)—In this paper the results are given of experiments instituted to determine the connection between the pressure and the temperature of fusion (see Phys. Soc. Abstracts, 1897, No. 183). The substances experimented on are benzine, ethylene bromide, paratoluidine, and naphtylamine.

The variation of the temperature of fusion corresponding to an increase of pressure of 1 atmosphere is obtained by finding

the variations for increments of pressure of 5, 10, 15, and 20 atmospheres and substituting in the equation—

$$t - t_o = ap - bp^2$$

thus obtaining values for a and b. The increments of temperature for 1 atmosphere, thus obtained, agree to 0·4 per cent. with those calculated by Clapeyron's formula.

The apparatus and method having thus been proved to give trustworthy results the experiments are continued to high pressures. In every case the curve of variation of temperature is found to agree very closely with an arc of a hyperbola.

The equation in the case of benzine is—

$$0{\cdot}00002109\ p^2 + 0{\cdot}003544\ pt - 0{\cdot}10598\ t^2 - 0{\cdot}030143\ p + t = o,$$

p being measured in atmospheres and t being the variation of temperature in degrees Cent. This equation gives a maximum increase of temperature of 4·528° at $p = 334{\cdot}2$ atmospheres, which agrees perfectly with the point where the curve becomes to all appearance parallel to the axis of pressure. The equation gives a subsequent fall in the curve which experiments have, however, failed to discover.

If we assume that the curve is part of a hyperbola whose asymptote is parallel to the axis of pressure, the agreement between the experimental curve and this hyperbola is not so close as it is with the first one.

Similar experiments on water give 0·00757° for 1 atmosphere as the lowering of the freezing-point. The curve in this case is only very slight, the concave side being towards the axis of pressure. The curvature is so slight that the equation to the curve cannot be obtained. The value of Joule's equivalent calculated from these experiments on water is 42·44 or 42·65, according as the latent heat is taken as 79·63 or 79·25.

J. B. H.

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802. *Variation of Specific Heat with Temperature.* **L. Sohncke.** (Wied. Annalen, 66. 1. pp. 111–115, 1898.)—The author compares the temperature coefficients of the specific heats of solids, liquids, and gases. For solids he finds they vary from 0·001 to 0·002, for liquids from 0·001 to 0·003, and for gases from 0·001 to 0·0025. From this close agreement he concludes that for all bodies in general, when the substance is not at a temperature near that at which it changes state, the alteration of the specific heat with temperature is determined principally by the increase of the internal energy of the molecules. From this it follows that the specific heat of bodies whose molecules contain only one atom, ought not to increase with temperature. For mercury and cadmium in the liquid and solid states respectively, a decrease of specific heat has been found. The author accounts

for this decrease by the diminution of the mutual action of the molecules on one another, owing to their increasing distances apart, due to the rise of temperature.

There are thus three physical properties of mercury which go to prove that its molecule contains only one atom. 1. The value of $\gamma = 1{\cdot}67$. 2. The fact that its specific heat volume constant in the gaseous state is one-half the specific heat in the solid state. 3. The fact that the specific heat in liquid state decreases with temperature. J. B. H.

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803. *Thermal Conductivity of Solids.* **F. A. Schulze.** (Wied. Annalen, 66. 2. pp. 207–223, 1898.)—In this paper a new method of determining the thermal conductivity of solids is described. A rod of the metal or other solid to be experimented on is allowed to assume a uniform temperature, preferably that of its surroundings. One end of the rod is suddenly brought to and kept at another constant temperature, either higher or lower than the temperature of the rod. This is done by a jet of water at the constant temperature being allowed to play on the end, and the end only. A thermoelectric junction gives the temperature at a point of the rod which is a few centimetres distant from the end in question. The times are noted by an electric chronograph, at which the galvanometer connected with this junction shows deflections of from 1 to 8 scale divisions. From the data thus obtained the conductivity is calculated. The mathematical analysis is given in the paper and the assumptions made are discussed and justified.

The results of eighteen different experiments on a copper bar are given, and the mean value for the conductivity obtained is $0{\cdot}6108$, the maximum variation being 4 per cent. and the probable error less than 1 per cent. J. B. H.

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804. *Thermal Conductivity of Glasses.* **A. Winkelmann.** (Wied. Annalen, 67. 4. pp. 794–802, 1899.)—The author replies to Focke's criticism of Paalhorn's work on the above subject, and maintains that the sources of error in the latter are not serious. He points out that lead glasses are very difficult to obtain of definite composition, since they take up alumina from the walls of the crucibles. One can never be certain that two glasses have the same composition unless they come from the same melting. Whatever differences there are between Focke's and Paalhorn's conductivities are probably due to a temperature change of the conductivity whose coefficient has not yet been determined.

E. E. F.

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805. *Aspiration-Thermometer.* **P. Fuchs.** (Zeitschr. Instrumentenk. 18. pp. 337–338, 1898.)—A substitute for Daniell's Hygrometer, consisting of a thermometer with a tubular passage through its quicksilver reservoir, which tubular passage is used for evaporating ether by aid of an aspirator, and thus cooling the mercury itself, more or less rapidly according to the aspiration. The instrument both indicates the temperatures and shows the dew-point, and is graduated down to about – 10° C. A. D.

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806. *Pressure of Water Vapour below Zero.* **M. Thiesen.** (Wied. Annalen, 67. 3. pp. 690–695, 1899.)—The author calculates the pressure of saturated water vapour over water and over ice respectively at temperatures down to – 80° C., on the basis of the equation of Clapeyron and Clausius. The following are some of the values:—

Temperature.	Pressure over ice mm. Hg.	Pressure over water mm. Hg.
0°	4·581	4·581
– 10°	1·946	2·145
– 20°	0·772	0·939
– 40°	0·096	
– 60°	0·008	
– 80°	0·0004	

E. E. F.

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807. *Gases which obey Joule's Law.* **F. Carré.** (Journ. de Physique, 7. pp. 718–719, 1898.)—A gas which follows the laws of Boyle and of Gay-Lussac, follows also Joule's law; such a gas is called a perfect gas. The converse does not always hold true. A gas whose laws of compressibility and dilatation may be represented by the equation

$$p\,(v-b)=\mathrm{RT}$$

would obey neither the law of Boyle nor the law of Gay-Lussac, but yet would obey Joule's law. The formulæ of Van der Waals, of Clausius, of Sarrau—those of the general type $(p+a)\,(v-b)=\mathrm{RT}$—are only applicable to gases which follow Joule's law. If, referring to Amagat's experiments, a gas is considered whose characteristic function takes the form

$$p\,(v-b)=\mathrm{RT}$$

it is certain that the gas follows Joule's law although it may always depart from Boyle's law. J. J. S.

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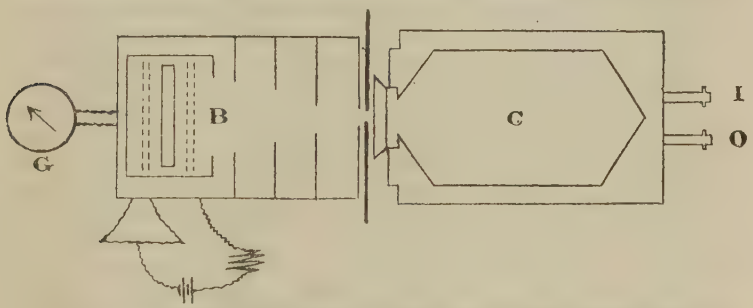
808. *Radiating Power of Platinum Black and Lampblack.* **F. Kurlbaum.** (Wied. Annalen, 67. 4. pp. 846–858, 1899.)—

All measurements of radiation depend upon the absorptive qualities of the thin layer which is deposited upon the sensitive surface of the bolometer or thermocouple. Most observers measure the maximum emission of the layer, in order to study its absorptive power. It is generally assumed that the emission increases at first with the thickness of the layer, and then decreases again when a certain thickness is reached, on account of the low conductivity of the black substance. The author compares the black surfaces with the ideal black body devised by Kirchhoff, and shows that very thin layers, which optically fulfil the requirements of absolute blackness within a few per cent., do not possess half the thermal absorption possessed by the ideal body. The method employed consists in determining the emission of layers of various thicknesses with the emission of the ideal body at the same temperature, say 100°. The measure of the thickness of the layer is its mass per square decimetre. The arrangement of the radiating body and the bolometer is shown in the diagram.



C is a brass cylinder blackened inside and closed at the ends by cones, one of which is truncated and serves to hold either the black surface or a diaphragm permitting the passage of the radiation from the ideally black interior of the cylinder. Steam is admitted through the pipe I and issues by O after circulating round the cylinder. The results show that the emissivity of lampblack increases much more rapidly with the thickness than does that of platinum black. The maximum for the former is attained at 30 mgr. per sq. dm., that of the latter at about 80. The maximum of intensity of the normal spectrum at 100° lies at about 8 m. For the short waves of the visible spectrum the absorption is much higher than for those of the maximum of absolute intensity. Both substances in layers of sufficient thickness sensibly obey the Stefan-Boltzmann law, and a considerable divergence from it means either a radiating layer of insufficient thickness or an insufficiently coated bolometer. For very long waves, both substances fail on account of their failure to absorb such waves. But for general purposes, platinum black is superior to lampblack, not only on account of its higher absorptivity and conductivity, but also because its deposition may be accurately governed by the electrolytic conditions. E. F. F.

809. *Distribution of Energy in Gases.* **E. Liveing.** (Cambridge Phil. Soc. Proc. 10. pp. 38–40, 1898.)—Some years ago Liveing and Dewar observed a very strong, diffuse, and easily reversed ray, with wave-length 2535·8, when mercury was introduced into the electric arc. Recently the author found that the same ray was produced by mercury heated in a flame of cyanogen burning in oxygen, which is nearly the hottest flame known. Another ray developed in the flame was that at 4358 in the indigo-blue. The emission of these two rays in a flame where the stimulus appears to be only the high temperature is a fact of some interest with regard to the atomic theory of gases. It proves that part of the heat communicated to the mercury is transformed into vibratory motion which affects the ether; and the true inference from the peculiar ratio of the specific heats of mercury vapour appears to be that, at the temperature at which this ratio is measured, the amount of heat converted into vibratory motion is very small compared with the amount which remains as heat. Experiments with a mixture of chlorine and hydrogen enclosed in a Kundt's tube made to sound by the usual method showed that at the temperature of the compressed gas in a sound-wave no sensible fraction of the heat is converted into vibratory motion, since no combination of hydrogen and chlorine took place. Still, this does not hold for higher temperatures, and so we must abandon the hypothesis that in gases energy communicated to the molecules is distributed equally in all the degrees of freedom. The hypothesis of gaseous atoms in the shape of rigid spheres is also disposed of since such atoms could not acquire any vibratory or internal form of motion from energy communicated to them as heat. It is possible that a chemically monatomic molecule may have, though it is not probable that it really has, a simpler constitution than a chemically complex molecule, and so may have not so many degrees of freedom as the latter, but still a plurality of degrees. E. E. F.

SOUND.

810. *Notes of High Frequency.* **F. Melde.** (Wied. Annalen, 67. 4. pp. 781–793, 1899.)—The methods for determining the pitches of high notes may be classified as subjective and objective. Among the subjective methods, one operates by direct comparison by the ear, and the other by the observation of difference tones. Both methods fail at very high pitches. Among the objective methods, one operates by a direct tracing of the vibration upon a surface moving at a known speed. In another two vibrations, one of a known and the other of the unknown pitch, are traced side by side. A photo-vibrographic method was devised in 1876 by S. T. Stein. Another was recently used by Appunn (see Abstract No. 445) for demonstrating the correctness of the pitches indicated on his small pipes. The author admits him to have proved that point, but maintains that his small forks have wrong pitches assigned to them. The author proceeds to give some further particulars of his own resonance method, which consists in transferring the vibrations to a rod sprinkled with fine sand. In conclusion, he points out the exceedingly great sensitiveness of flames to notes, and more especially to notes of the highest pitches. If an effective method would be devised for photographing their changes, and making them discriminate between various pitches, a very valuable means for studying high pitches would be available. E. E. F.

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811. *Velocity of Sound.* **A. Leduc.** (Comptes Rendus, 127. pp. 1201–1203, 1898.)—This paper on the velocity of sound in air at 0° C. contains a criticism of corrections to be applied to the results of Violle and Vautier, and a defence of the value obtained by the author himself. J. B. H.

ELECTRICITY.

812. *Electromagnetic Theory.* **O. Heaviside.** (Electrician, 42. pp. 183–185, 1898, and pp. 410–412, 1899.)—Continuation of a series of articles on this subject. EDITOR.

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813. *Electrostatic Lines of Force.* **V. Boccara.** (N. Cimento, 8. 4. pp. 406–408, 1898.)—A curious method of demonstrating the lines of force in a gap between ball and ball, between ball and disc, or disc and disc, or point and disc, by smearing the terminals with liquid, say castor oil. When the electric machine is set at work, spray flies between the terminals in such a way as to demonstrate the directions of the lines of force. A. D.

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814. *Brush Discharge.* **E. H. Cook.** (Phil. Mag. 47. pp. 40–57, 1899.)—The phenomena considered are produced by the discharge of positive or negative electricity from a point connected to a Wimshurst machine. The author gives diagrams showing the shape of the positive brush for differently shaped pointed conductors, and points out that whereas the positive brush starts at a slight distance from the conductor the negative one begins on the conductor, except in rarefied gases. Measurements of the force of the wind from points are given, in which the repulsion of a balance pan by the discharge is observed; the results show that the positive brush exerts a slightly greater force for the same potential, and the force is felt by a light vane at a greater distance, than in the case of the negative brush. After referring to the effect of the brush in charging distant conductors the author describes experiments on the formation of ozone and the oxidation of ferrous salts by the brush discharge, from which it appears that the negative brush has by far the greater chemical action. A discharge from a copper point close to the surface of nitric acid does not cause the acid to receive any observable trace of copper; the points apparently do not disintegrate.

Experiments made with photographic plates show that the source of the actinic rays, as determined from the sizes of shadows of objects between the plate and the point, is the point itself and does not coincide with the origin of the visible brush. Photographic effects are produced after reflection, either from a metallic or a glass mirror. Other points of similarity to light are noted; measurements of the comparative intensities of candle-light and the discharge indicate that although the latter is of small illuminating power it is relatively rich in actinic rays. J. L. H.

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815. *Electrical Discharge in a Magnetic Field.* **A. Broca.** (Journ. de Physique, 7. pp. 710–717, 1898.)—The author describes his experiments on the discharge with Crookes tubes and also with gases under ordinary pressure, and comes to the conclusion that there exists two sets of kathode rays—those of the first kind which follow the trace of a helix described round the direction of the lines of force, and those of the second kind which follow the direction of the lines of force. His experiments support the view of Crookes as to the nature of kathode rays. These seem to consist of assemblages of molecules identified with those of luminous sources. Experiments on the arc discharge corroborate this view. The material motions which produce the emission of radiations from an incandescent gas and those of the kathode rays in a Crookes tube appear to the author as two phenomena of the same order, but different through the form of the motions, the different forms of the electric discharge in gases presenting all the intermediate cases between the two extreme ones. J. J. S.

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816. *Cooling Effect of Gases traversed by Electric Discharge.* **E. Villari.** (N. Cimento, 9. pp. 77–87, 1899.)—The passage of electric sparks through gases causes them to produce a cooling effect on a platinum spiral in the neighbourhood of the sparks. If the spiral is heated by a current the resistance decreases, and this decrease furnishes a means of measuring the cooling effect. Experiments are described in which the current through the spiral is maintained constant by adding a variable external resistance to compensate the decrease in the resistance of the spiral. It is found that the change of resistance is small when the temperature of the spiral is low (corresponding to feeble currents); it increases with increased currents up to a maximum, beyond which it diminishes again. These results are obtained, with varying degrees of difficulty, in the case of oxygen, hydrogen, coal-gas, and carbon dioxide. The cooling action is increased on making the sparking more intense by using a larger primary current in the induction coil; an increase in the capacity of the condenser connected to the secondary circuit has, however, the opposite effect. Diminution of the pressure of the gas results in a diminished cooling, small at first but very marked when the pressure is only a few millimetres of mercury.

In a later series of experiments, using screens and reflecting surfaces suitably arranged between the spark-gap and the spiral, it is shown that the cooling is due to the impact of cold gas particles against the hot spiral, the particles being projected from the spark terminals. That such mechanical movements exist is demonstrated by the behaviour of tobacco smoke introduced at the bottom of the bell-jar in which the experiments are conducted. As soon as the sparks pass, the smoke is violently agitated and diffuses throughout the whole of the jar. On the other hand, a

current of gas, through which sparks have been previously passed in another vessel, produces no greater effect than unelectrified gas.

The behaviour of nitrogen peroxide is anomalous. It produces a heating of the spiral, and it scarcely disturbs tobacco smoke lying at the bottom of the bell-jar. This action is not attributable to its density, because bromine, which is much more dense, is similar in behaviour to the other gases examined. The author calls attention to differences in the mode of diffusion of smoke through different gases; such diffusion is not directly related to the density of the gas. J. L. H.

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817. *Residual Phenomena in Crookes Tubes.* **A. Sandrucci.** (Roma, R. Accad. Lincei, Atti, 8. pp. 108–115, 1899.)—The apparent after-action, the continued emission of kathode rays in high-vacuum tubes after the induction coil has ceased working, are imitated by unipolar effluvia; it appears to be due to an action in the existing apparatus. It depends on the tube and on the degree of vacuum and is sensitive to external electrostatic charges. Experiments in progress. A. D.

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818. *Kathode and Röntgen Rays and Atomic Dimensions and Density.* **G. Guglielmo.** (N. Cimento, 9. pp. 131–142, 1899.) —Different means of measuring the diameters of molecules may be resolved into means of measuring the intensity of the circum-molecular field of force at different distances from the centre—and therefore different methods do not necessarily yield identical results. J. J. Thomson, W. Wien, and Lenard have shown reason for believing that the kathode rays consist of particles much smaller than a molecule, and moving with a velocity little less than that of light. The aggregates of such particles known as chemical atoms or as molecules seem to present the same obstructing area as the sum of the areas of the particles themselves; so that the kathode rays must freely traverse a molecule; and atoms of different atomic weights seem to consist of similar such particles, in larger or smaller aggregations. The diameter of the particles, from Röntgen ray absorption data, works out as of the order 1×10^{-13} and the absolute density about 80,000 kgr. per cubic cm. But this diameter really represents the effective obstructive area during the passage of kathode rays: and may be smaller, since the obstructive area covered during the passage is affected by the transverse vibratory movements of the particle: which consideration harmonises with the increase in the absorption brought about by higher temperatures, electric excitation, or impact of luminous waves. Kathode rays of smaller velocities are more affected by the obstruction offered by the particles they have to pass, and the absorption is accordingly greater. The

absorption of Röntgen rays is not sufficient to be consistent with their being flights of material particles ; and they must be ether-perturbations, wanting in periodicity. A filament of glass rendered fluorescent by kathode rays appears blurred when looked at through a thick stream of kathode rays, at right angles to their track ; which would point to ether-perturbations along the course of these intervening kathode rays. A. D.

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819. *Phase of Hertzian Oscillations.* **M. Abraham.** (Wied. Annalen, 67. 4. pp. 834–841, 1899.)—In discussing the apparent anomaly that near the point of radiation the magnetic component of a Hertzian wave should have an infinite velocity, the author shows during the proper oscillations of a solid of revolution, which are symmetrical to its axis, the phase of the magnetic force is propagated with infinite velocity into the surrounding space from the surface of the conductor, but that with increasing distance its velocity approaches asymptotically to the velocity of light. Of course it must not be supposed that the "phase" precedes the disturbance in space. The phase calculated for any one point only applies to it from the moment that the state of damped periodic oscillation has been established there. Now, since the disturbance is always propagated with the velocity of light, it follows that the wave emitted proceeds with varying phase. As regards a rod conductor, the oscillations at a great distance are the same as if the phase of magnetic force had traversed a path equal to half the length of the rod with infinite velocity.

E. E. F.

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820. *Neugschwender's Wave Detector.* **E. Aschkinass.** (Wied. Annalen, 67. 4. pp. 842–845, 1899.)—Instead of a narrow gap in a silver-on-glass mirror, as used by Neugschwender (see Abstracts, No. 567, 1899), the author employs two bent copper wires with pointed ends, which lightly touch each other. When immersed in methyl alcohol or in air these wires show the ordinary coherer action. But when they are immersed in water, or, better still, when a drop of water is put on the junction, electric waves produce an increase of resistance which continues as long as the waves impinge, and ceases when they cease. The same effect is produced in an ordinary coherer when the filings are wetted. But in both cases the promptness with which the original conductivity is restored is impaired by a prolonged action of the waves. This suggests some temporary modification of the conducting substance, which is gradually reversed on withdrawing the modifying influence. The fact that the galvanometer shows a deflection even after the current is withdrawn indicates polarisation. There is also a kind of fatigue. When waves pass in quick succession, they must be stronger and stronger to produce

the same effect, unless the indicator is artificially shaken. The most exact indications are given when the galvanometer current is comparatively strong. E. E. F.

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821. *Electro-capillary Phenomena.* **S. W. J. Smith.** (Roy. Soc. Proc. 64. pp. 253–255, 1899.)—A discussion of the Lippmann-Helmholtz theory of the capillary electrometer and a description of experiments which support the view that the first assumption of the Lippmann-Helmholtz theory is true and that the second is not. (Cf. on this subject Phys. Soc. Abstracts, No. 667, 1896; S. Meyer's experiments.) J. J. S.

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822. *Electrothermal Relations.* **W. Voigt.** (Wied. Annalen, 67. 4. pp. 717–740, 1899.)—The author gives the complete formulæ of his theory of the Ettinghausen-Nernst thermomagnetic E.M.F.s and their inversion, the galvanomagnetic heat currents. E. E. F.

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823. *Damping of Galvanometer Needles.* **H. Lemke.** (Wied. Annalen, 67. 4. pp. 828–833, 1899.)—The author shows that Schering's formula for the period, amplitude, and logarithmic decrement of a magnetic needle subject to a damping action may be simplified by regarding the motion of the needle as the sum of three simple damped oscillations. For the period he obtains an equation of the type—

$$T=\frac{\pi}{\beta}-\left(\frac{C_1}{C\beta}\sin D_1+\frac{C_2}{C\beta}\sin D_2\right)\left(e-\frac{2\varepsilon\pi}{\beta}-1\right)$$

E. E. F.

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824. *Resistance of Lead Amalgams at Low Temperatures.* **G. W. Gressman.** (Amer. Soc. Proc. 47. pp. 117–118, 1898.) Amalgams were made containing various proportions of lead, ranging from 25 per cent. lead to pure mercury. The specimens were contained in little U-tubes of bore from 1 to 2 mm., and were cooled to a temperature below their freezing-points by a bath of ether and carbonic snow. The freezing-point of the amalgam was very sharply indicated by a sudden change in the resistance, the resistance of the solid amalgam being sometimes only one-fifth that of the liquid. The temperature coefficients of the amalgams between ordinary temperatures and the freezing-point was found to be nearly constant. The more lead in the amalgam the lower the temperature coefficient, which was extremely small in the case of the 25 per cent. amalgam. This amalgam, which is only

semi-liquid, shows a strange break in its resistance curve near 30° the coefficient being apparently positive for temperatures below, and negative for temperatures above this point. E. C. R.

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825. *Measurement of Resistances containing Earth Currents.* **R. R. Black.** (Electrician, 42. pp. 416–417, 1899.)—An adjustable resistance R is put in series with the resistance x, to be measured, and it is connected to a Wheatstone's Bridge in the usual manner. The adjustable arm D is adjusted to give a balance, the battery is then reversed, a balance being again obtained by altering R to R_1, then—

$$x = \frac{A}{B} \cdot D - \frac{R + R_1}{2}$$

As a rule it is best to make D about 25 per cent. higher than the estimated value of $\frac{B}{A}x$, and obtain a balance in each case by adjusting R. E. C. R.

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826. *Raymond-Barker's Insulation Test for Cable Joints.* **A. D. Constable.** (Elect. Rev. 43. pp. 37–40, 1898.) (See 1898, Abstract No. 932.)—An illustrated description of a trough applicable to the test, and hints are given for intercepting possible leakage. An analysis is made of the electrical conditions, both of the simpler test and of the absolute *null* method, using Thomson-Varley slides. The insulation of the joint may not only be proved satisfactory or the reverse, but may be worked out in megohms. One of the condensers may be dispensed with.
M. O'G.

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827. *Thermal Ammeter.* **C. Camichel.** (Séances Soc. Franç. Phys. 1. pp. 61–65, 1898.)—The thermal ammeter devised by the author (see 1899, Abstract No. 118), and recently improved, consists of a U-tube filled with mercury, and with one of its branches slightly drawn out in the middle. Into the narrow portion is introduced a mercury thermometer whose bulb is slightly less in diameter than the internal diameter of the tube. Two platinum electrodes plunge into the branches of the U-tube, and serve to convey the current to be measured. The heat developed is almost all concentrated round the thermometer, and the rise of the latter within a given time indicates the current strength. In the improved pattern, the U-tube is narrowed at its lowest portion, so as to produce a thin thread of mercury there. The thermometer bulb is made to enclose this thread, and thus measures the heating without loss by radiation. The heating is

directly proportional to the square of the current. The apparatus as constructed measures currents from 1 to 0·05 ampere within 1 or 2 per cent. Its indications are extremely constant.

E. E. F.

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828. *Commercial Potentiometers.* **Gosselin.** (Soc. Int. Elect. Bull. 15. pp. 246–268, 1898.)—This paper gives the principles of the potentiometer as applied to the measurement of E.M.F.s, potential differences, and currents, and a description of the potentiometers devised by G. Chaperon, R. E. Crompton, Elliott Bros., Nalder Bros. and Co., Janssen and Fiugner, of Hanover, &c. The paper is illustrated with skeleton diagrams of most of the forms, as well as illustrations of the complete apparatus.

E. C. R.

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829. *Alternate Current Arcs.* **W. Duddell** and **E. W. Marchant.** (Instit. Elect. Engin. Journ. 28. pp. 1–106, 1899.) This paper describes experiments made on the alternate current arc by means of oscillographs. The oscillograph is a form of d'Arsonval galvanometer of very short periodic time and critical damping; it is formed by stretching, in a narrow gap between the poles of an electromagnet, two parallel conductors formed by bending a metal strip over a pulley; at the bottom of the gap the ends of the strip are clamped to a block, and a bridge piece at the top of the gap presses against the strips. The current to be measured flows up one strip and down the other, thus causing one to move forward and the other backward, and turning a mirror attached to them through an angle which, if small, is proportional to the current. The necessary damping is obtained by immersing the strips and mirror in a chamber filled with oil. The spot of light from the oscillograph mirror was examined by a rotating mirror or thrown on to a rapidly moving photographic plate.

The paper is very fully illustrated with curves from photographs obtained by this method, which give the P.D. at the terminals of the dynamo, that at the terminals of the arc, and the current. The following are some of the results obtained:—

1. If a resistance in any alternate current circuit is replaced by an arc which transmits the same r.m.s. current, the wave forms of P.D. between its terminals and the current through it are no longer the same, and the r.m.s. value of the P.D. between its terminals is increased.

2. With high voltage solid carbons and *small* self-induction in the circuit, the P.D. arc wave is flat-topped, with a high front and smaller back peak: the current remains small for a considerable part of the period; the power factor is low, and the arc is unstable.

3. With high voltage solid carbons and *considerable* self-induction in the circuit, the P.D. arc wave is rectangular, with much

smaller peaks; the current no longer remains small for any sensible time; the power factor is higher, and the arc is much more stable.

4. With soft-cored carbons, the reaction is generally small; the P.D. arc wave has a dent in the front side; the power factor is nearly unity, and the arc is very stable.

5. With one solid and one soft-cored carbon, the reaction is intermediate. At any instant the nature of the carbon which is positive determines to a large degree the reaction at that time.

6. Increase of arc length with solid carbons first increases both peaks in the P.D. arc wave until the hissing-point is reached; further increase of length produces a high front peak and no back peak. Very long arcs with all kinds of carbons give a P.D. wave with a large front peak. The power factor, with solid carbons, decreases with increase of length up to the hissing-point, and then increases; with cored carbons the power factor is generally higher for longer arcs.

7. The large front peak on the P.D. wave for long arcs is due to the high resistance of the gaseous column after each extinction of the arc.

8. The distribution of the fall of P.D. in the alternate current arc is similar at any instant to that in the direct current arc.

9. Resistance in series has little effect on the P.D. arc curve, but causes the current wave to become more like the open-circuit wave of the particular machine used; the larger the resistance the greater this effect.

10. Lowering the frequency increases the reaction, increases the peaks with the solid carbon arc, and the time during which the current is small, in all cases. It reduces the power factor and stability, but improves the efficiency.

11. With transformers having a very small magnetic leakage, *i.e.*, designed for constant secondary P.D., the distortion of the secondary wave forms is accompanied by a similar distortion of the primary wave forms. With transformers having a large magnetic leakage and intended to give constant current the distortion is not appreciably transmitted from the secondary to the primary circuit.

12. The distortion of the wave forms by the arc occurs with all makes of carbons, the amount depending on the hardness and impurities contained.

13. Foreign bodies in the arc generally reduce the reaction, and lower the r.m.s. value of the P.D. for a given length and current. Small quantities of the salts of the alkali metals may be used to lower the voltage at which the arc burns, but they probably also reduce the efficiency.

14. Arcs between carbons and metals are generally unidirectional, the currents flowing much more easily from the metal to the carbon. The more rapid cooling of one electrode facilitates the flow of current from it, and resists the flow towards it.

15. Enclosing the arc increases the reaction, the front peak on

the P.D. arc wave becoming more marked. The r.m.s. value of the P.D. is raised, and the power factor reduced.

16. The reaction still occurs when the arc is only part of the load on the alternator.

17. The reactions are more marked with arcs in series.

18. With arcs between unequal carbons the current is larger when the larger carbon is positive.

19. When the direct current arc hisses, the P.D. and current vary very rapidly; these variations in the case of a solid carbon arc have a frequency of 1,000 per second, and take place so that an increase of current is accompanied by a reduction of P.D.

20. In all questions relating to the alternate current arc the distortion of the wave forms by the arc must be taken into account, as these distortions considerably affect the efficiency, the stability, and the power factor. E. C. R.

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830. *Electric Arc.* **F. Eichberg** and **L. Kallir.** (Wien. Akad. Sitzber. 107. pp. 657–680, 1898.)—This paper is somewhat fuller than that by the same authors which appeared in Eclair. Elect. 17. pp. 560–566, 1898. (See 1899, Abstract No. 679.)

Results are given of experiments with alternating arcs between electrodes of carbon and electrodes of iron, aluminium, copper, and nickel. With all these metals the apparent constant currents and constant differences of potential in the direction metal-carbon are approximately the same. This fact leads the authors to the conclusion that the cause of the excess current in one direction cannot be an opposing E.M.F. in the arc due to the metal and carbon electrodes, as this opposing E.M.F. would vary for different metals. They conclude that the cause is due to greater resistance in the one direction than in the other through the arc.

Photographs of the different arcs are given in the paper.

J. B. H.

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831. *Magnetic Induction in Electrical Measuring Instruments.* **A. Campbell.** (Phil. Mag. 47. pp. 1–18, 1899.)—Two methods of measurement were principally used. 1. When the magnetic fluxes were not alternating, a search coil in circuit with a ballistic galvanometer either had the flux suddenly reversed in it or was pulled quickly out of the field. 2. When the flux was alternating, the search coil was connected to a resistance coil laid along one set of junctions of a minute thermopile, which was connected to a sensitive galvanometer. For a given frequency the mean square of the P.D. at the terminals of the search coil was proportional to the deflection on the galvanometer. If the resistance of the search coil be negligible and the flux follows the sine law

$$v_2 = 10^{-8} \times 2\pi n N_2 B S_2$$

where v_2 = voltage shown by galvanometer, n = frequency, N_2 = number of turns in search coil, S_2 = area of search coil, and

$$B = \sqrt{\text{mean square of flux.}}$$

The values of B are given for a large number of instruments, including a variety of electric supply meters.

Experiments made with a Siemen's electro-dynamometer turned to the four points of the compass gave a maximum variation of 2·1 per cent.

In a Weston voltmeter a variation of 0·1 per cent. was detected in the higher readings when its position with respect to the earth's field was altered. E. C. R.

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832. *Florian's Mariner's Compass.* **E. Gelcich.** (Zeitschr. Instrumentenk. 18. pp. 339–340, 1898.)—To make the compensation of compasses as simple as possible, H. Florian employs invariable "correctors" for the vertical fore-and-aft plane and the thwart plane respectively. When the correctors are vertical their deviating effect is nil. The deviation of the needle increases with the inclination of the correctors to the vertical. Each corrector is provided with a divided circle on which the amount of artificial deviation is marked against each angle of inclination.

Florian's "deflector" is based upon the principle that if a bar magnet is mounted on land in a place free from iron above a compass needle in such a manner that the centres of the magnet and the needle are in the same vertical, and the magnets themselves make an angle of 45°, the directing force of the needle becomes invariable when the deflector is made to deflect the needle by 90°. A scale indicates for every horizontal intensity the position corresponding to the suitable position of the deflector on land. If then the apparatus is brought on board an iron vessel, the needle will show a deflection different from 90°. The deviation constants are thus easily determined. To avoid both octantal and sextantal deviation, there must be four needles, and the angles they make normally with the NS lines must be 52·5° and 7·5° respectively. E. E. F.

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833. *Magnets of Different Steels.* **A. Abt.** (Wied. Annalen, 66. 1. pp. 116–120, 1898.)—This paper contains a comparison of the magnetic moments of similar magnets made of different steels and magnetised in the same fields, the fields being increased step by step until all the magnets were saturated. The magnetic moment of the magnet of Wolfram steel is about twice that of any of the others. It loses its magnetism, however, faster than some of the others, losing 26·5 per cent. in 122 days. J. B. H.

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834. *Hysteresis and Temperature.* **A. M. Thiessen.** (Amer. Assoc. Proc. 47. pp. 115–117, 1898.)—A preliminary communication containing an account of some experiments undertaken to ascertain the law connecting hysteresis loss with temperature for temperatures below the freezing-point. It is known that, for temperatures above 0° C. the hysteresis loss for a given maximum of B decreases with rise of temperature. On the other hand, Fleming and Dewar have found that, at the temperature of liquid air the hysteresis loss in soft Swedish iron is practically the same as at ordinary temperatures. The author's experiments show that, for temperatures between about −70° C. and 0° C. the hysteresis loss for a given induction decreases with rise of temperature. The measurements were made by the ballistic method, the specimens being in the form of rings about 5 cm. in diam. and 1 sq. cm. in section. The lowest temperature was obtained by immersing the ring and magnetising coil in a bath of ether containing dissolved CO_2 (a layer of gutta-percha being used as a protective covering). Three specimens were tested: one of soft wrought iron, another of tool steel, and a third of nickel steel. In each case there was a decrease of hysteresis loss with rise of temperature. A. H.

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835. *Hysteresis.* **F. Niethammer.** (Wied. Annalen, 66. 1. pp. 29–48, 1898.)—The magnetic hysteresis in iron is here investigated under the following different conditions: 1. When the magnetisation is increased in the ordinary step by step method, the induction being measured ballistically. 2. When the magnetisation is produced by alternating currents, the hysteresis being taken as the ratio of the maximum induction to the maximum field. 3. When the iron is rotated in a uniform magnetic field. 4. As in 1, but with no reversal of current, so that the field only varies from a maximum to zero and is never reversed.

The principal portion of the paper is devoted to the magnetisation by alternating currents. An iron ring is used, which is built up of 400 ring plates insulated from each other by paper. The sectional area of the ring is 135 cm.^{2}, the volume 925 cm.^{3}, and the mass of iron 72·17 kg. The ring is wound with 96 turns, uniformly distributed on the circumference.

The main electric circuit contains, besides the magnet, an electrodynamometer, a wattmeter, and a non-inductive resistance. A multicellular voltmeter measures the effective E.M.F., and a Joubert disc and ballistic galvanometer serve to determine the curves of E.M.F. and current.

The maximum value of H during a period is obtained from the geometry of the ring magnet and the maximum value of the current during the period. Calculation shows that owing to the ring form of magnetic circuit, H may vary by 2 per cent. over the section.

The maximum induction during a period is obtained from the curve of E.M.F. since the total induction :—

$$B6 = \frac{1}{2\pi}\int_0^{\pi} \text{edt.}\, 10^8$$

from which B is found. In the paper, tables are given containing the values of B, H, μ, N (frequency), A (the wattmeter reading) and cos ϕ (the ratio of A to the product of effective current and E.M.F.).

The B-H curve for N = 37 lies above that for N = 59, and both lie much below the magneto-static curve determined as in 1. This lowering of the curve with increase of frequency cannot be accounted for by Foucault currents or by shielding, and the author attributes it to a real diminution in the value of the hysteresis with increase of frequency.

To determine Steinmetz coefficient the value of A is corrected for the energy lost in Foucault currents in the iron. The total energy lost is—

$$A = V\{\eta N B^{1\cdot 6} + \varepsilon N^2 (C_d B)^2\}\, 10^{-7}$$

where the first member is the energy lost by hysteresis and the second that lost by Foucault currents. Taking the results of experiments with two different values of N the frequency, the second member of the equation can be eliminated between the two equations and a value of η obtained. The paper gives values of η corresponding to values of B from 1400 to 13600. These are by no means constant, $\eta = 0{\cdot}00259$ for B = 1400 then for B = 2700 $\eta = 0{\cdot}00291$; η then falls to 0·00257 for B = 7600 from which point it continues to rise with B, being 0·00368 for B = 13600.

Experiments are made with E.M.F. curves of different forms, but the form does not seem to have any great effect on the results ; departures from sine curves tend, if anything, to bring the B-H curves slightly nearer the magnetostatic curve.

The magnetostatic experiments give variations in the values of η which correspond with those for alternating currents, but the values of η themselves are smaller for the magnetostatic experiments than for the others.

The results of magnetostatic experiments without reversal of the current are given for values of H from 1·8 to 27, the corresponding values of $\frac{B_2 - B_1}{2}$, varying from 278 to 2010, and η from 0·00192 to 0·00686.

For the experiments on rotation in a magnetic field the armature of a continuous current dynamo is used. It is driven by a motor, and the energy required to drive the motor is noted both when the dynamo armature is in and when out of, a magnetic field. The energy lost by Foucault currents is eliminated from

the results of two series of experiments with different speeds of rotation. The values of η obtained vary from 0·00305 for B = 14,010 to 0·00119 for B = 4495. Vibration seems to have no effect on the loss due to hysteresis. J. B. H.

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836. *Magnetic Susceptibility of Water.* **G. Jäger** and **S. Meyer.** (Wied. Annalen, 67. 3. pp. 707–713, 1899.)—The magnetic susceptibility was determined by two additional methods. A glass tube was attached to one arm of a balance and exposed to a magnetic field. After determining the magnetic pull upon the empty tube, it was filled with water and the new magnetic pull was observed. It was found to be $-0{\cdot}146$ g. with a tube 1·5 sq. cm. in internal sectional area. The values obtained for the susceptibility were $-0{\cdot}665 \times 10^{-6}$ on an average. Manganese chloride of sp. gr. 1·160 at 15° gave $+20{\cdot}8 \times 10^{-6}$, and ferric chloride (42·2 per cent.) gave $+47{\cdot}47 \times 10^{-6}$.

Another method consisted in observing the velocity of efflux of water from a narrow orifice when that orifice was brought into a strong magnetic field. This was, however, only applied successfully to the measurement of the susceptibility of ferric chloride solution. The value thus obtained was $47{\cdot}1 \times 10^{-6}$, which agrees with the last result remarkably well. All the methods hitherto employed by the authors give results not differing by more than 2 per cent. The mean result for water is

$$k = -0{\cdot}689\ (1 - 0{\cdot}0016t) \times 10^{-6}.$$

E. E. F.

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837. *Chemical Action of Magnetism.* **E. Jahr.** (Elektrochem. Ztschr. 5. pp. 177–180, 1898.)—Dry photographic plates are not affected by a magnet; but if they be brought within 1 mm. of the polar ends of a bundle of 40 magnetised steel wires each 10 cm. long by 1 mm. thick, while the sensitive surface is immersed in the developer (pyro 2, sulphite soda 15, carbonate potash 6, water 500) or even in distilled water, with exposures from 1 to 10 minutes, the plate is found to have been affected. Reproductions of the negatives are given in the paper. Electromagnets act similarly. Unmagnetised iron has no effect. The metal was kept, by wax and waxed paper, from contact with the liquid. A. D.

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838. *Meteorological and Magnetic Phenomena.* **v. Rijckevorsel.** (Phil. Mag. 47. pp. 57–65, 1899.)—This is a continuation of the work referred to in Abstract No. 900 (1898). The author has drawn curves showing the annual range of tempera-

ture, horizontal force, declination, vertical force, rainfall and barometric pressure for various stations in Europe. He finds a similarity between the curves for the various elements. Thus the maxima and minima are in general repeated in all the curves, though they sometimes occur earlier in some than in others.

From a consideration of the temperature curves for the various stations in Europe, particularly of the minimum in June and the maximum in July, the author concludes that the June minimum is due to some disturbing cause travelling from the West coast of Scotland southwards, and the July maximum to a similar disturbing cause approaching Europe from the South.

The author concludes that there is some common cause which rules all the meteorological and magnetic phenomena, and which influences them all in a similar way and almost simultaneously.

W. W.

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839. *Magnetic Inclination Deduced by Magnetisation of Clay.* **G. Folgheraiter.** (Roma, R. Accad. Lincei, Atti, 8. pp. 69–76, 1899.)—The author shows how observations of the free magnetism of certain cylinders, which have been baked, whilst subject to the action of the earth's magnetic field, can be applied to calculate the directions of the magnetic axes of the cylinders, and hence to estimate the magnetic inclination. The estimated values only differ by one or two degrees from the true values. He obtains equally good results with specially prepared vases and amphoras.

The bearing on the determination of the dip in ancient times is obvious.

A. Gs.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

840. *Atomic Weights.* **F. G. Wiechmann.** (Science, 9. pp. 23–24, 1899.)—The author gives the values which are recommended for adoption in analytical practice by a commission appointed by the German Chemical Society, consisting of H. Landolt, W. Ostwald, and K. Seubert. Some of these are given below. The last decimal place may be regarded as accurate except in the cases of nickel, bismuth, and tin.

Name.	Atomic Weight.	Name.	Atomic Weight.
Aluminium	27·1	Iron	56·0
Antimony	120	Lead	206·9
Arsenic	75	Magnesium	24·36
Barium	137·4	Manganese	55
Bismuth	208·5	Mercury	200·3
Boron	11	Nickel	58·7
Bromine	79·96	Nitrogen	14·04
Cadmium	112	Oxygen	16·00
Calcium	40	Phosphorus	31·0
Carbon	12·00	Platinum	194·8
Chlorine	35·45	Potassium	39·15
Chromium	52·1	Silicon	28·4
Cobalt	59	Silver	107·93
Copper	63·6	Sodium	23·05
Fluorine	19	Strontium	87·6
Gold	197·2	Sulphur	32·06
Hydrogen	1·01	Tin	118·5
Iodine	126·85	Zinc	65·4

T. E.

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841. *Recently Discovered Gases.* **W. Ramsay.** (Science, 9. pp. 273–280, 1899.)—The lightest fraction of atmospheric argon contains helium, argon, and a new gas, neon. These are separated by means of their different solubilities in liquid oxygen, helium being the least, argon the most soluble. The purest neon obtained had the density 10·04 and 10·19, and the refractivity 0·338 compared with air. The wave-lengths of the most important lines in its spectrum are 6402, 6383, 6335, 6267, 6218, 6164, 6143, 6096, 6074, 6030, 5853, 5401, 5341, 5331, 4716 (?), 4722, 4710, 4709, 4704. The heaviest fraction of atmospheric argon contains three gases—metargon, distinguished by giving the spectrum of carbon monoxide when mixed with oxygen, krypton, and xenon. The last, in an impure condition, has the density 32·5, and like argon possesses two spectra. By thrice-repeated fractional distillation of liquid argon, rejecting the

lightest and heaviest fractions, a purified sample was prepared which was again liquefied and distilled in six fractions. With the exception of the first, which contained a little neon, these had practically the same density and the same refractivity. The mean density was 19·96. (See 1898, Abstract No. 1370.) T. E.

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842. *Twinning of Crystals.* **F. Wallerant.** (Comptes Rendus, 127, pp. 1250–1252, 1898.)—While, according to Mallard's law, crystals frequently twin so as to supply elements of symmetry deficient in their molecular network, the network of the twins being parallel and the molecules arranged symmetrically with reference to these elements, the author supposes that in other cases the orientation of the molecules in the twins is parallel, the networks being arranged symmetrically to elements of symmetry deficient in the molecules. Since a molecule, contrary to a network, may possess an axis of symmetry of any order (viz., five, &c.) very complicated systems are possible; fluor spar and marcassite are adduced as examples. B. B. T.

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843. *Vapour Pressure of Solutions.* **C. Dieterici.** (Wied. Annalen, 67. 4. pp. 859–870, 1899).—The author examined the vapour pressures of aqueous solutions at 0° C. whose concentrations were between normal and decinormal solution. The error of method was great, since the accuracy depended upon the certainty with which two vessels, one containing water and the other the solution, could be brought to the same temperature. A difference of temperature of 0·0025° means a difference in vapour pressure of 0·001 mm. of mercury, and since the decrease of pressure of the decinormal solution of a non-electrolyte only amounts to about 0·008 mm. altogether, the results obtained are of little quantitative value. The author is, however, enabled to draw two general qualitative conclusions. The first is that within the concentrations specified no decrease of vapour pressure with decrease of concentration is observed in electrolytes. The second is that Raoult's law, which makes the decrease of vapour pressure independent of the nature of the solute, and simply dependent upon the number of molecules dissolved, does not apply to aqueous solutions of non-electrolytes. That, of course, does not exclude the possibility of both phenomena occurring at greater dilutions. E. E. F.

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844. *Hydrogen and Platinum.* **A. Mior.** (N. Cimento, 9. pp. 67–76, 1899.)—Platinum goes on absorbing hydrogen up to about 8·4 times its volume, the process taking, say, eight months at ordinary temperatures, but being accelerated by warming the metal. When it has taken up this maximum, warming the metal will not induce it to take up any more. A. D.

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845. *Heat Developed on Wetting Powders.* **G. Ercolini.** (N. Cimento, 9. pp. 110–116, 1899.)—The heat developed rises with successive additions of liquid up to a maximum, and on further additions of liquid the heat developed remains constant, and does not fall back as T. Martini asserts it does. A. D.

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846. *Dissociation of N_2O_4.* **A. Pochettino.** (Roma, R. Accad. Lincei Atti, 8. pp. 183–188, 1899.)—Values of k/c, the ratio between the two specific heats, found at various temperatures from 4° C. to 150° C., by sound-velocity measurements by Kundt and Wüllner methods. The value of the ratio increases with the temperature from 1·169 (for N_2O_4, at 4°.2 C.) to 1·300 (for NO_2, at 140° C.). The changes of value agree with the hypothesis that the gas at intermediate temperatures consists of mixtures of N_2O_4 and NO_2, according to Gibbs' law (Amer. Journ. Sci., xviii. p. 279, 1879) of gradual dissociation with increasing temperatures. A. D.

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847. *Properties of Aluminium.* **A. Ditte.** (Annal. Chim. Phys. 7. pp. 152–162, 1899.)—This paper deals with the difficulties experienced in getting aluminium to enter into chemical combination, although its heat of combination shows that it should rank as a metal very easily acted on by acids, and one which should decompose water. This seeming immunity from chemical action is due to two causes: 1. The coating of alumina which forms so quickly on any fresh surface; 2. The film of hydrogen with which the aluminium is surrounded almost immediately after being put into water or acid. By arranging the conditions so as to prevent these from forming, continuous chemical action can be obtained.

The film of hydrogen can be got rid of by working in a partial vacuum, and, by suitably arranging the substances present, the formation of alumina may be prevented. For instance, aluminium in a solution of common salt would give aluminium chloride and soda with evolution of hydrogen, but the soda reacts with the aluminium chloride, giving alumina and common salt again; so the result is that only the water takes part in the action. If, however, we introduce acetic or some other weak acid to combine with the soda and prevent it reacting with the chloride, the solution of the aluminium continues so long as any free acid is present. The other cases dealt with can all be explained in a similar way. J. B. H.

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848. *Solution Theory of Iron and Steel.* **H. J. von Jornstorff.** (Engineering, 66. pp. 763–764, 1898.)—Roberts-Austen's experiments show that the eutectic alloy of iron and carbon, con-

taining 4·3 per cent. of carbon, freezes at 1130°. From solutions containing less carbon pure iron crystallises out, and from those containing more carbon graphite separates. Taking the absolute freezing-point of iron as 1873°, and its molecular heat of fusion as 20 (this latter number being very uncertain), the molecular depression of the freezing-point may be calculated by means of van't Hoff's formula. By means of this number and Roberts-Austen's freezing-point curve the author finds that the molecular weight of carbon dissolved in molten iron increases with the concentration from 24·54 to 31·27. The heat of dissolution of carbon in molten iron is also calculated from its solubility by means of a formula analagous to that applying to ordinary solutions, as 1419 cals. per gramme.

Similar calculations are made for silicon and carbon dissolved in molten iron, and for the separation of ferrite and perlite from solid solution, but the experimental data appear to be insufficient to give any reliable result. T. E.

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849. *E.M.F. and Heat of Formation of Alloys.* **M. Herschkowitsch.** (Zeitschr. Phys. Chem. 27. pp. 123–166, 1898.)—Part I.—*E.M.F. of Alloys.* Laurie's results were open to the objection that they were not always obtained with solutions containing a salt of one of the metals under examination. The author has therefore repeated them under more favourable circumstances, and by stirring the electrolyte and using a constant current-intensity, has obtained a fresh series of results. The method of observation, giving results accurate to 0·1 millivolt is described. In each of the experiments a series of binary alloys was examined, starting with one metal pure and gradually adding increasing proportions of the other metal in each successive test until the series ends with the other metal pure. Thus :—

Cadmium-Tin alloys opposed to cadmium in normal cadmium sulphate solution show practically the same potential difference from 100 per cent. Cd to the alloy with a molecular percentage of 2·7 Cd, the rise of potential then becoming more and more abrupt up to 100 per cent. Sn. The solubility of solid cadmium in solid tin is rather over 1 molecule per cent., whilst that of tin in cadmium is almost *nil.*

Cadmium-Lead alloys under similar conditions showed the beginning of the abrupt rise in P.D. when the Cd in the alloy had been reduced to 3·6 mols. per cent. The solubility of Cd in Pb is a little over 4 mols. per cent.

Cadmium-Bismuth alloys under similar conditions showed the same P.D. throughout the series. These solid metals are therefore scarcely, if at all, mutually soluble.

Zinc-Tin alloys opposed to zinc in normal zinc sulphate solution showed the first abrupt rise when the zinc had been reduced to 3·47 mols. per cent.

Zinc-Copper alloys under similar conditions showed a P.D. of

about 5 millivolts from 100 per cent. Zn down to 69 mols. per cent. Zn, when it rapidly rose to about 700 millivolts for the alloy with 66 mols. per cent. Zn (*i.e.*, Zn_2Cu); beyond this point the curve of P.D. gradually becomes less steep, showing a P.D. of about 1,130 millivolts for pure Cu opposed to pure Zn. This and other observations explained confirm the view that the alloy Zn_2Cu is a chemical compound.

Zinc-Bismuth alloys under similar conditions show no sudden rise of potential until the Zn is reduced to 5·86 mols. per cent.

Zinc-Silver alloys under like conditions show a marked increase in P.D. when the Zn is reduced to 82·6 mols. per cent., and then an abrupt and great rise when the Zn is between 80 and 77 mols. per cent. There is every indication therefore that Zn_4Ag is a chemical compound.

Zinc-Antimony similarly shows a sharp rise at the point when the zinc is reduced to the percentage corresponding to $ZnSb_2$.

Tin-Copper alloys opposed to tin in saturated stannous chloride solution show one abrupt change of potential at the point corresponding to the chemical compound Cu_3Sn.

Tin-Silver alloys, similarly, gave the rise in P.D. with the compound Ag_4Zn; the absence of any abrupt change at the point corresponding to Ag_2Zn seems to negative the assumption based on observations of other properties that Ag_2Zn also is a true compound.

Copper-Silver alloys, opposed to copper in normal copper sulphate solution, show a gradual rise of P.D.

Part II.—*Heat of Formation of Metallic Alloys.* The heat of formation of certain alloys was determined on Hesse's principle and by a modification of Andrews' method. The pure metals alone were acted upon by bromine solution in a calorimeter under suitable conditions, which are described at length; and after applying certain necessary corrections, the heats of formation of the pure bromides are thus obtained. The metals after alloying are then treated with bromine in the same way. The difference between the heats of formation of the salts formed from an alloy of determined composition and those of the same weights of salts obtained from the unalloyed metals gives the heat of formation of the alloy under examination. Zinc and tin, cadmium and zinc, and copper and tin absorb heat in alloying, whilst copper-zinc forms an exothermic compound, the maximum heat evolved being given out when the metals are nearly in the proportion Zn_2Cu.

W. G. M.

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850. *Validity of the Dilution-Law.* J. J. van Laar. (Zeitschr. Phys. Chem. 25. pp. 79–90, 1898.)—The author maintains: 1. That the Ostwald dilution-law is the true dissociation-law for *all* electrolytes. 2. That the Rudolphi-van't Hoff form is not a true dissociation-law. 3. That the latter only represents conductivity results in solutions of highly dissociated electrolytes owing to a

secondary circumstance, viz., the Joule heat produced during the passage of the current. 4. That for the same reason the electrical determination of degree of dissociation is incorrect. The author bases the arguments for 1 and 2 on a formula previously deduced by himself. Noyes has, however, shown recently that this formula is not correct (Zeit. Phys. Chem. 26. p. 699).

The arguments in favour of 3 and 4 may be sufficiently characterised by the fact that the Joule heat is supposed to heat up the ions and salt-molecules to a very much higher temperature than the surrounding water. It is only fair to say, however, that this paper has given rise to a controversy between van Laar and Noyes, and that this is still in progress. F. G. D.

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851. *Solubility of a Binary Electrolyte in a Solution of another having Different Ions.* **A. A. Noyes.** (Zeitschr. Phys. Chem. 27. pp. 267–278, 1898.)—This paper is an application of the principles of the theory of ionisation to certain special cases. The author starts out from three sets of equations, viz.: 1. The analytical data of the solution (which involve the solubility to be calculated). 2. His own *Solubility-laws* (*i.e.*, constancy of the ionic "solubility-product" and of the amount of undissociated salt present in a solution, when the corresponding solid phase is in equilibrium with the solution). 3. The electrolytic dissociation-equations for the various possible electrolytes. Under 3 he employs for highly dissociated electrolytes the Rudolphi-van't Hoff equation in the more general form $\frac{C_1 C_2}{C_0^{\frac{4}{3}}} = \text{const.}$, where C_1 and C_2 are the concentrations of the positive and negative ions, and C_0 that of the undissociated salt. Supposing now CD to be the binary electrolyte already present in the solution, and AB the one whose solubility therein is to be determined, the reaction occurring in the solution is AB+CD=AD+CB. The author then shows how the solubility of AB can be calculated by suitable approximation-methods in the following cases: 1. AD or CB highly dissociated. 2. CD and AD (or CB) highly dissociated. 3. AD or CB highly dissociated. Between the values so calculated and the results of experiments carried out by the author and his pupils there is a most satisfactory agreement. F. G. D.

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852. *Chemical Equilibrium between Amalgams and Solutions.* **A. Ogg.** (Zeitschr. Phys. Chem. 27. pp. 285–311, 1898.)—After some preliminary remarks on the Nernst theory of the equilibrium between metallic complexes and solutions, the author proceeds to investigate the equilibrium between metallic mercury and silver nitrate solution. The silver displaced from the solution dissolves in the mercury, and a state of equilibrium is reached,

where we have Mercury + Ionic Silver $\rightleftarrows$ Silver + Ionic Mercury. The author takes the active mass of the silver in this reaction as proportional to its concentration in the mercury, and the active mass of the mercury as constant. Hence if a = concentration of ionic silver, b = concentration of ionic mercury, c = concentration of silver in the amalgam, we obtain a/cb = const. or $a/c\sqrt{b}$ = const. according to whether mercury exists in the solution as a *monovalent* or *divalent* ion. The experiments of the author verify the *second* of the above formulæ. This result is confirmed by an investigation of the equilibrium between metallic mercury and a solution containing mercurous and mercuric nitrates, and by experiments on concentration cells and on conductivity, according to the well-known methods. Reference is also made to the freezing-point results of Canzoneri (Gazetta Chim. [2]. 23. 432, 1893). In the above experiments a solid amalgam is found to separate when the concentration of the silver in the mercury reaches a certain value. The author investigates its composition by methods analogous to those which are now generally used for hydrated salts, and finds it to be Ag_3Hg_4. A calculation of its heat of formation (7336 gr. cal.) and some measurements on the "decomposition – E.M.F.'s" of solutions of silver and mercurous nitrates conclude the paper. F. G. D.

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853. *Equilibrium in Water—Alcohol—Succinonitrile System.* **F. A. H. Schreinemakers.** (Zeitschr. Phys. Chem. 27. pp. 95–122, 1898.)—Solutions of the above nitrile, either in water or alcohol, are capable of forming two layers, the separation-temperatures being 18·5° – 55·5° and 13° – 31° respectively. Therefore between 18·5° and 31° two cases are possible in the system of all three components: the separation may take place for all proportions of alcohol to water, or mixtures may exist which remain homogeneous on adding nitrile. The latter is found to be the case between 56·1 per cent. and 71·4 per cent. alcohol. Solubilities are determined from – 5° to 55°, and isotherms calculated from 4·5° to 18·5°. B. B. T

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854. *Equilibrium in Water—Sal Ammoniac—Iron Chloride System.* **E. C. J. Mohr.** (Zeitschr. Phys. Chem. 27. pp. 193–221, 1898.)—The work of B. Roozeboom (Zeitschr. Phys. Chem. 10. 145) is extended to higher temperatures, curves being determined for 25°, 35° and 45°. Of these the first two are similar to that for 15° and show very slight increase in solubility of the double salt. The curve for 45° except for the disappearance of the hydrate $2FeCl_3.12H_2O$, which melts at 37·5°, is also similar. Two new double salts $FeCl_3\,NH_4Cl$ and $2FeCl_3\,NH_4Cl.4H_2O$ are discovered and are investigated crystallographically: the latter is regular and is the salt previously taken to be regular ferric

chloride. The solubility curve for the previously known double salt $FeCl_3\ 2NH_4Cl\ H_2O$ is such that, especially at high temperatures, evaporisation of a saturated solution may cause first a precipitation and afterwards resolution, as was observed for $PbI_2KI.2H_2O$ by Schreinemaker. B. B. T.

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855. *Pressure-Temperature Diagrams for Binary Systems.* **W. D. Bancroft.** (Journ. Phys. Chem. 3. pp. 1–11, 1899.)—A discussion, from an abstract point of view, of the pressure-temperature relations in systems containing two independently variable constituents. The only novelty is that the partial-pressure curves for the two constituents are shown in the diagrams. No experimental work is given. The author considers the effect of a solvent action in the vapour phase, *i.e.*, an increase in the sublimation-pressure of one of the solid constituents due to the presence of the other in the vapour. He also considers the effect of solid solutions, and concludes by showing that there is no anomaly in the fact that solutions saturated with respect to anhydrous sodium sulphate have, when in the metastable or instable region a lower vapour-pressure than the stable solutions saturated with respect to decahydrate. F. G. D.

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856. *Cryoscopic Measurements of Sodium Mellitate.* **W. W. Taylor.** (Zeitschr. Phys. Chem. 27. pp. 361–363, 1898.)—Sodium mellitate, $Na_6C_{12}O_{12}+17H_2O$, being the sodium salt of a hexabasic acid should dissociate in very dilute solution into seven ions and the molecular depression of the freezing-point should approximate to seven times the normal value. The molecular depression observed is 3·77 times the normal value (1·87) in a solution containing 0·0277 gram molecule per litre, increasing to 5·92 times the normal value in a solution containing 0·00181 gram molecule per litre. T. E.

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857. *Cryoscopic Investigation of Derivatives of the Terpenes.* **W. Biltz.** (Zeitschr. Phys. Chem. 27. pp. 529–551, 1898.) Substances containing the hydroxyl group, when dissolved in benzene or naphthalene, give abnormally small molecular depressions of the freezing-point; this indicates the existence of polymeric molecules, the degree of polymerisation increasing with the concentration. The author finds that this is strikingly exemplified by the oxygen derivatives of the terpenes, among these the ketones, aldehydes, and oxides show no tendency to polymerise whilst the alcohols all do so. The polymerisation is greatest with primary, least with tertiary alcohols. T. E.

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858. *Exact Cryoscopic Measurement.* **F. M. Raoult.** (Zeitschr. Phys. Chem. 27. pp. 617–661, 1898.)—The errors of the thermometer are first considered. The apparatus used for the freezing-point determination consists essentially of a glass tube completely surrounded by a mantle filled with ether, the temperature of which can be exactly regulated by blowing air through it. Surrounding the bulb of the thermometer is a helix of platinum foil, which rotates at constant velocity with the thermometer, and acts as stirrer. In making a measurement the solution is first supercooled 0·5°, the temperature of the ether mantle brought to 0·1° below its freezing-point, and finally the separation of ice induced. The freezing-point of the solvent is determined in exactly the same way, both before and after that of the solution. The influence of the cooling-bath is entirely eliminated when its temperature is such that the convergence temperature of the solution coincides with its freezing-point. For the author's apparatus it is found experimentally that the convergence temperature is 0·1° higher than the temperature of the ether when the stirrer is making 5 revolutions per second. The difference of temperature is due to the friction of the stirrer. When the freezing occurs below the convergence temperature (as is usual in the older methods) ice often separates from pure water as a solid mantle, whilst from solutions it usually separates in small crystals. In the first case the apparent freezing-point is higher, in the second lower than the true freezing-point, and consequently the depression found may be several hundredths of a degree too large. The influence of supercooling is best determined experimentally by making determinations with different degrees of supercooling, from which the true freezing-point is obtained by extrapolation. (See 1898, Abstract No. 130.) Dissolved oxygen and nitrogen depress the freezing-point of water by 0·00083° for each cc. dissolved in 100 cc. of water. After allowing for all errors, the method is accurate to 0·001°. T. E.

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859. *Ionisation and Chemical Composition.* **J. J. Thomson.** (Cambridge Phil. Soc. Proc. 10. pp. 10–14, 1898.)—A current of electricity passing through Röntgenised gas increases with the electromotive force but approaches a finite limit (the "saturation-current"), which is attained when the number of ions used up by the current in one second is equal to the number of ions produced in that time by the rays. Therefore, to compare the ionisation in two gases we have only to compare their saturation-currents *when exposed to rays of the same intensity*. Experimental methods of controlling this criterion, and screening the gas against secondary effects, are described. The saturation-currents are as follows: Air = 1·00; H_2 0·33, N_2 0·89, O_2 1·10, CO_2 1·40, CO 0·86, NO 1·08, N_2O 1·47, C_2N_2 1·05, C_2H_2 1·00; H_2S 6; SO_2 6·4; HCl 8·9; Cl_2 17·4; NH_3 = 1 (?) Ammonia was doubtful, as it was found difficult

to dry the gas. With the exception of cyanogen, the gases given follow an additive law, following the factors for atoms [H] 0·165, [N] 0·445, [O] 0·55, [C] 0·3, [S] 5·3, [Cl] 8·7 ; thus for C_2H_2 the saturation-current is (air being unity) $\{(2\times0\cdot3)+(2\times0\cdot165)\}=0\cdot93$ calculated as against 1·00 observed. The results for CO_2, N_2O, SO_2, and HCl do not differ much from those of Perrin ; but for H_2 and NH_3 they are about ten times as great. The existence of this additive law indicates that the ionisation produced by the rays is probably not the separation of one atom from another in the molecule of a gas, but a process occurring in the atom itself.

A. D.

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860. *Spectroscopic Test of Ionisation.* **E. Liveing.** (Cambridge Phil. Soc. Proc. 10. pp. 40–44, 1898.)—While the absorption bands produced by solutions of didymium chloride and nitrate respectively have the same positions, general character, and intensities, so long as the solutions are equivalent and moderately dilute, yet more concentrated equivalent solutions show unequal variations in the intensities of the absorptions, some being stronger with the nitrate and others stronger with the chloride.

Equivalent solutions of the sulphate, nitrate, and chloride give absorptions which are indistinguishable from each other. This is in accordance with the theory which has been worked out by Ostwald, that dilute solutions of salts which have one and the same coloured ion, with various colourless ions, all show the same absorptions.

Comparing the effects of the same thickness of solutions of the various degrees of dilution, we find in the region between λ 522 and λ 365 :—

1. That all the bands produced by the dilute solutions are strengthened, in both chloride and nitrate, in the stronger solutions, and also widened, the more diffuse being most widened. The narrow, sharply defined band about λ 427 retains its character, but is nevertheless sensibly widened.

2. The difference between the nitrate and chloride is that the light on the more refrangible side falls away in the spectrum of the chloride, from about λ 420, at a more rapid rate than in the spectrum of the nitrate. It is as if a broad, weak absorption, beginning from the more refrangible part, gradually extended down to the violet region in the chloride but not in the nitrate.

If we accept the theory that the absorptions common to the salts in dilute solutions are due to their common ions, namely, the didymium and other metallic ions, then these broad absorptions, which appear to be added when a stronger solution of the chloride is employed, may be ascribed to the undecomposed chloride, or they may possibly be due to the chlor-ion. But the latter alternative is highly improbable.

Throughout the series the absorption bands which are common to the chloride and nitrate are always, except in the most dilute solutions, a little stronger for the chloride than for the nitrate, the difference being more pronounced for stronger solutions. This may be accounted for by supposing a larger proportion of the chloride to be ionised than of the nitrate.

Generally the observations tend to confirm the theory of Ostwald, but much more extended observations are needed, and some with other salts are already in progress. The effects of temperature will be taken in hand as soon as possible.

It is difficult to see how the ionisation theory of solution can be tested spectroscopically in any other way, at least until we have learnt what the spectroscopic characters of the ions are. It is not possible, with our present knowledge, to predict the properties of ions, except so far as to say that, since the ions differ in their intrinsic energies from the elements of the salts ionised, it is almost certain that they will differ in their properties too.

E. E. F.

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861. *Cause of Dissociative Power of Solvents.* **J. W. Brühl.** (Zeitschr. Phys. Chem. 27. pp. 319–322, 1898.)—The author points out that similar considerations to those he put forward regarding oxygen (Zeitschr. Phys. Chem. 18. p. 514, 1895) will apply to nitrogen as a determinating constituent of compounds as regards high dielectric constants and power of ionising electrolytes; this is so in the case of liquid NH_3 (Cady. Journ. Phys. Chem. 1. 707, 1897. See 1898, Abstract No. 188) the nitrites and nitroparaffins (Dutoit. Compt. Rend. 125–240, 1897, and Bull. Soc. Chim. 19. 321, 1898), and he suggests that such properties may also be looked for in other unsaturated atoms, as sulphur in the mercaptans and organic sulphides, phosphorus in PCl_3, and possibly carbon in the acetylene compounds. B. B. T.

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862. *Galvanic Cells.* **G. Platner.** (Elektrochem. Ztschr. 5. pp. 150–153, 1898.)—The author deals with the solution of the zinc in galvanic cells, and with a depolariser of his own. Zinc can dissolve in a solution of sodium chloride under formation of zinc hydrate and generation of hydrogen, even in the absence of oxygen, because all metallic chlorides undergo hydrolytic dissociation in water. The cell contains zinc chloride as $Zn(OH)_2$. $2HCl$, which takes up more zinc "until the whole of the acid has been converted into insoluble basic salt." He confirms this theory of hydrolysis, which had already been advanced by Kippenberger in 1895, by referring to Tommasi's thermal constants. The hydroxide and acid molecules of the hydrolysed chloride would not be independent of one another, but remain combined, as in the case of the guanidin salts $CN_3H_5.HCl$; they would become separated,

however, when further aqueous molecules intervene. What the closing of the circuit has to do with the phenomena is not explained. The depolariser is chlorate of sodium. Platner's ferri-sulphate cell has an E.M.F. of 1·98 volts; but its internal resistance soon becomes very high. In order to combine the continuous generation of oxygen from the chlorate, which is independent of the current, with depolarisation proper, he fills the interior of his carbon electrode with sodium chlorate, and surrounds the electrode with manganese dioxide. The cells are not described. H. B.

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863. *Osmotic Theory of the Galvanic Cell.* **W. Nernst** and **E. Bose.** (Zeitschr. Elektrochem. 5. pp. 233–235, 1898.)—According to the above theory the potential difference between a metal and a solution depends on the concentration of the metallic ions in the solution. Two mercury electrodes immersed, the one in normal sulphuric acid saturated with mercurous sulphate, the other in normal sulphuric acid alone, show very little difference of potential. When, however, by means of two secondary platinum electrodes, the minute quantity of mercury contained in the acid in contact with the second electrode is removed by electrolysis, a difference of potential of as much as 0·443 volt is obtained. With silver electrodes in 0·01 normal hydrochloric acid, the acid surrounding one of them being saturated with silver chloride, a difference of potential of 0·423 volt is similarly obtained. When the two electrodes are connected through 100,000 ohms, the potential difference immediately falls, owing to the extreme readiness with which the electrode in contact with the practically metal-free solution is polarised. T. E.

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864. *Electrodes of the Third Kind.* **R. Luther.** (Zeitschr. Phys. Chem. 27. pp. 364–366, 1898.)—These are electrodes reversible with respect to a metal which decomposes water. For example, a lead plate immersed in a solution of a calcium salt, saturated with both calcium sulphate and lead sulphate. The P.D. between lead and solution depends on the concentration of the lead ions; this depends on the concentration of the SO_4 ions, which in its turn is dependent on the concentration of the calcium ions. This last, therefore, determines the P.D. between the lead and the solution, and the electrode behaves as though it were a peculiar metallic modification of calcium with a special solution pressure. The choice of materials for electrodes of this kind is somewhat limited, owing to the necessity of excluding secondary chemical reactions between them. T. E.

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865. *Carbon in Electrolytic Iron.* **L. Houllevigue.** (Journ. de Physique, 7. pp. 708–709, 1898.)—Electrolytic iron is generally considered the purest that can be obtained; it is, however, far from being so. Besides the large quantities of hydrogen (100 to 150 times its volume) found in it, there are numerous other impurities. The author considers the important one, carbon, and gives the result of experiments in which the soluble electrode consisted of a strip of steel with 0·4 per cent. of carbon, which was placed in a bath of chlorides of iron and ammonium. Heated to 900°, and tempered above 630°, this specimen of steel is composed of carbon dissolved in iron, but not combined; whilst the same steel, cooled slowly, is composed of pure iron and combined carbon. When the steel electrode was so treated as to be of the first class, electrolytic iron extremely poor in carbon was obtained (0·017 per cent. at the most). On the other hand, an anode of steel cooled slowly after being heated to 900° furnished an iron comparatively rich in carbon (from 0·033 to 0·035 per cent.).

Thus electrolysis appears to affect in a different way tempered steel and steel that is cooled slowly. Carbon dissolved in steel is not carried along with the current; it remains as a muddy deposit at the surface of the anode. Combined carbon, on the contrary, is carried along with the iron in the direction of the current. Combined carbon seems to constitute a complex ion, which is carried all-of-a-piece on to the kathode. J. J. S.

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866. *Electrolytic Production of Nitrobenzene.* **C. Schall** and **R. Klein.** (Zeitschr. Elektrochem. 5. pp. 256–259, 1898.)—Fused ortho-nitrobenzoic acid alone is but a feeble conductor of electricity, but when soda is dissolved in it it conducts readily. In the experiments recorded such a solution was electrolysed at a temperature of 160°–200° C. in a special apparatus described in the text, whereby gas was produced at both electrodes, and the solution became dark in colour, and emitted a smell of nitrobenzene. A solution of 6·4 grm. of soda in 50 grm. of the nitro-acid, treated with a current of 0·8–1·0 ampere from 9 chromic acid or 6 Bunsen elements in series, yielded as a distillate about 1 cc. of nitrobenzene in the space of one or two hours. Carbon dioxide was identified as being produced at the anode. But the action cannot be due to the union of two anions with separation of carbon dioxide, as in this case orthodinitrodiphenyl would result, and not nitrobenzene. W. G. M.

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867. *Electrolytic Preparation of Dithio-disulphides.* **C. Schall** and **S. Kraszler.** (Zeitschr. Elektrochem. 5. pp. 225–226, 1898.)—The authors refer to a previous paper (Zeits. f. Elektrochemie, iii. p. 83) in which the action of the electric current upon

bodies of the general formula RCSSM is dealt with. These appear to split up under the action of the current according to the following equation :—

$$2\ RCSSM = 2\ RCSS + 2\ M = (RCS)SS(SCR) + 2\ M.$$

The same product is obtained by chemical methods by the action of iodine.

Since the publication of the original paper, further experiments upon organic bodies of this type have shown that the electrolytic method does not always yield the corresponding dithio-disulphide, and the authors have undertaken further work, of which the present paper is the record, to throw light upon these deviations from the general rule. This part of the paper does not admit of useful abstraction. In the course of their work they have obtained a new dithiodisulphide by electrolysis of the ethyl trithio substitution product of potassium carbonate. The new body has the formula $(C_2H_5.SC)S - S(CS.C_2H_5)$.

All the dithio-disulphides are oily liquids incapable of crystallisation. J. B. C. K.

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868. *Organic Electro-Chemistry.* **M. Krüger.** (Elektrochem. Ztschr. 5. pp. 185–190, 1898.)—This is a continuation of the author's previous historical papers (see 1898, Abstract No. 1185, and 1899, Abstract No. 489), and relates to the reducing action of electrolytic hydrogen upon organic bodies in acid or alkaline solution. W. G. M.

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869. *Electro-deposition of Vanadium.* **S. Cowper-Coles.** (Chem. News, 79. pp. 147–148, 1899.)—Brilliant, almost silver-white deposits of metallic vanadium are obtained by dissolving 1·75 parts of vanadic anhydride and 2 parts of caustic soda in 160 parts of water, adding 32 parts of hydrochloric acid, and electrolysing the solution at about 180° F. with a current density of 18 to 20 amperes per square foot, and an E.M.F. of 1·88 volts. With higher or lower current densities, or at low temperatures, reddish-brown oxide is deposited along with the metal. N. L.

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870. *Electrolytic Analysis.* **G. Arth.** (Écl. Électr. 18. pp. 88–91, 1899.)—A summary of recent communications by Neumann, Hollard, and Kaeppel upon methods of electrolytic analysis.

Neumann deals with the electrolytic determination of nickel, and describes experiments in which sulphate solutions containing varying amounts of iron were used as the electrolyte. The method which his experiments lead him to recommend allows the nickel

to be determined with a maximum error of 0·5 per cent., due to deposition of iron with the nickel.

The determination of lead in the commercial metals and alloys containing it is the subject of Hollard's paper. The lead is deposited as peroxide at the anode.

Kaeppel deals with the estimation of manganese. He has found that the addition of acetone to the electrolyte renders the deposition of the manganese as manganese-peroxide much more satisfactory. In spite of this improvement, it is not yet possible to determine by electrolysis the amount of manganese in solutions containing excess of iron. The determination of the iron in presence of manganese can, however, be carried out by use of sulphate solutions containing sodium pyrophosphate, and details of an improved method of carrying out this electrolysis are given.

The references to the original papers are given in this article, and for full details these should be consulted. J. B. C. K.

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871. *Electrolytic Estimation of Cadmium.* **E. Rimbach.** (Zeitschr. Analyt. Chemie, 5. pp. 284–290, 1898.)—Large experience of Beilstein and Jawein's electrolytic method of estimating cadmium has convinced the author of the convenience and accuracy of the process, notwithstanding the objections which have been raised to it. The best results are obtained by adding about 3 grammes of potassium cyanide to the neutralised solution of the chloride or sulphate of the metal occupying 150–200 cc., and electrolysing for 12–16 hours at the ordinary temperature with an E.M.F. of 3·0–3·3 volts, and a kathode current density of 0·02–0·04 ampere per square decimeter. The metal is thus obtained as a firm, coherent, silver-white deposit, and the test analyses quoted are very satisfactory. Contrary to Thomälen's experience, excellent results were obtained by the use of from 3 to 5 Meidinger cells instead of a storage battery. Cadmium may, by this process, be estimated in the presence of aluminium, tin, copper, &c., but if the metals are present as nitrates it is necessary to increase the kathode current density to about 0·4 ampere per square decimeter in order to obtain complete precipitation. If magnesium is present, sufficient ammonium chloride must be added to keep this metal in solution. N. L.

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872. *Electro-metallurgical Industries of England.* **J. B. C. Kershaw.** (Electricity, N.Y., 14. pp. 344–345, 1898.)—This article is a continuation of that previously noticed. (See 1898, Abstract No. 962.) The works of the British Aluminium Company at Foyers, and of Messrs. Bolton & Sons, at Froghall and Widnes, are dealt with.

At Foyers, aluminium has been produced since June, 1896; 3,500 H.P. is stated to be utilised between the two manufactures carried on there—aluminium and calcium carbide. The power is generated by five turbines, working under 350 feet head of water, each generating 750 H.P. The armatures of the dynamos are keyed on to the same vertical shaft, and weigh fourteen tons. Three more sets of generating machinery are to be installed. The total power available at Foyers will then be 6,000 H.P. Details of the capital and profits of this Company are given.

At Froghall and Widnes, Messrs. Bolton & Sons carry on the electrolytic refining of copper. At Froghall, four Corliss valve triple expansion condensing engines are in use. These drive eight Elwell-Parker continuous current dynamos, each 75 kw. Rope gearing is used. At Widnes two Galloway slow-speed engines drive by belts four dynamos similar in design and size to those at Froghall. The total production capacity of the two works is about 12,000 tons copper per annum.

Views showing the generating machinery at Foyers and at Widnes, and the copper-depositing vats at the latter place, are given. AUTHOR.

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873. *Electrolytic Vats.* **H. Becker.** (Ind. Électrochim. 2. pp. 57–58, 67–68, 73–74, 89–91, 1898.)—A serial, giving brief abstracts of the more important patents.

In No. 8 (pp. 57–58) the patents of Watt (1851), Wastchuk and Glukoff (1880), Hoepfner (1884), Philipps (1885), Greenwood (1888–1890–1891), Richardson and Holland (1890), and of Richardson (1891), are briefly described.

No. 9 (pp. 67–68) contains abstracts of the following patents: —Le Sueur (1891), Kellner (1891), Cutten (German P., No. 69,461), and Blackman (German P., No. 69,087).

In No. 10 (pp. 73–74) the patents of Andreoli (German P., No. 75,033), Faure (German P., No. 70,727), the Union Chemical Company (1893), Blackmore (?), Gorgensen (1894), Drake (1894), Roberts (1892 and 1894), Lucius and Bruning (French P., 1894), Gall and Montlaur (French P., No. 240,697), Outhenin Chalandre et Cie (German P., No. 73,964), Hulin (German P., No. 81,793), Bain (German P., No. 84,549), Blackman (U.S.A. Patents 541,146 and 541,147), and Straub (German P., No. 73,662), are dealt with.

All the above electrolysers are designed for the production of soda and chlorine, without any preliminary separation of the alkali metal at the kathode.

In No. 12 (pp. 89–91) electrolysers designed for the production of carbonates or other compounds of the alkali metals are described. These include those of Hargreaves-Bird (carbonates), Hermite and Dubosc (aluminates), and of Parker and Robinson (oleates and stearates).

The following electrolysers in which the sodium is separated in the form of an amalgam are also briefly described in this number:—

Rolf (1882), Hermite (1888), Hermite and Dubosc (German P., No. 67,851), Atkins and Applegarth (German P., No. 64,409), and Castner (1892).

Except in the case of the Castner and the Hargreaves-Bird electrolysers, no details of the yield or efficiency of the various forms of cells are given. In these two instances, the figures given by the inventors in 1894 and 1895 respectively are quoted.

J. B. C. K.

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874. *Efficiency of Electrolytic Vats.* **C. F. Burgess.** (Elect. World, 32. pp. 686–688, 1898.)—The author gives expressions for the energy efficiency (ratio of change in chemical energy to electrical energy), and also for the quantity efficiency of an electrolytic vat. There is also the electrical efficiency, or the ratio of the E.M.F. of polarisation to the applied pressure. Methods are described for the measurement of polarisation of vats, that in use at the University of Wisconsin being given in detail. It is advisable to measure the polarisation at both anode and kathode, by means of a normal electrode, so that losses may be located. Curves are reproduced showing the variation of polarisation with current. W. R. C.

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875. *Electro-deposition of Gold.* **E. Andreoli.** (Electricien, 16. pp. 268–270, 304–306, and 340–343, 1898.)—Articles upon the electro-deposition of gold in the Transvaal. EDITOR.

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876. *Memmo Carbide Furnaces.* (Zeitschr. Elektrochem. 5. pp. 197–200, 1898.)—Memmo's two furnaces (English Patents 24,077 and 14,022 of 1897) are described at length. In the former, which is said to possess many faults, the carbon rods forming one pole pass vertically into a melting-chamber with graphite walls and bottom, the latter being hollowed like the hearth of a reverberatory furnace to facilitate the removal of the carbide formed, and being, moreover, itself movable. The charge is fed in through a hopper at one side; the evolved gases (carbon monoxide and hydrogen) may be recovered by means of a stop-cock attached to a closed chamber constructed of sheet iron, which forms the upper part of the furnace, and through which the carbon-rod electrodes are passed, gas-tight, by means of a stuffing-box. In the other furnace the heating chamber is of cast iron lined with refractory material, the bottom consisting of a graphite plate in an iron frame capable of being moved up and down, piston-like, in a steel tube. The carbon-rod electrodes are arranged

horizontally, or nearly so, and pass through the side walls of the heating chamber, the number of rods depending upon the character of the current used ; for direct or single-phase alternating currents two rods, for two-phase three, and for three-phase currents four, rods being employed. The ends of the rods must be in the centre of the hearth, and each rod is therefore passed air-tight through an iron sleeve, and its position is made adjustable by means of screw-gear. Above the heating chamber, and connected with it by a narrow neck, is an upper compartment of iron lined with refractory material and provided with an air-tight lid ; this serves to contain the charge, which is fed by means of a screw to the space above the arc. The water-gas formed by the reaction of the calcium hydroxide and carbon is collected, and may be burnt with air and so used to pre-heat the charge. The furnace may be used if necessary for heating by incandescence instead of by the arc, in which case thin rods of carbon or of some badly conducting material are placed between the carbon electrodes, and are thus raised to incandescence by the current. W. G. M.

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877. *Enclosed Electric Furnace.* (West. Electn. 24. p. 52, 1899.)—This is an account of a novel calcium carbide furnace with which an experiment was conducted at the Armour Institute of Technology, Chicago. The novelty consists in employing a heavy carbon anode, pierced with a hole about 1½ in. square, through which the pulverised mixture of 60 per cent. lime and 40 per cent. coke was fed on to a sort of hollow carbon hearth, which formed the other electrode.

It is proposed to use this form of enclosed furnace to take advantage of the increased temperature and to enable the operation to be carried on continuously, so long as the carbons last, which is estimated at about a week. So far, however, the tests have not been in any way conclusive, and, chiefly owing to difficulties in feeding, the longest trial made appears to have been only forty minutes.

The American Carbide Co. propose to erect a plant at Maquoketa, Ia., with an initial capacity of 1,000 H.P.

J. L. F. V.

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878. *Electric Furnaces.* **G. Richard.** (Écl. Électr. 18. pp. 15–20, 1899.)—An illustrated description of the Wood, Memmo, Roberts, Crees, Durban, and Gore, Siemens, and Maxim electric furnaces. W. G. R.

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879. *Electric Furnaces.* **F. J. Patten.** (Elect. World, 32. pp. 413–416, 1898.)—A description of various furnaces.

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880. *Curve of Accumulator Charge.* **P. Girault.** (Ind. Élect. 7. pp. 453–455, 1898.)—The equation of the current time curve of an accumulator is shown to be of the form

$$i = A + B\epsilon^{-mt}$$

if it be charged at constant potential. A, B, and m are derived analytically, and the result compared with a couple of experiments on a Blot cell. M. O'G.

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881. *Faure-Sellon-Volckmar Motor Car Accumulators.* (Ind. Élect. 7. pp. 523–524, 1898.)—The plates are of pure lead with very small perforations. The lightest type (3.6 watts per kilogram of complete cell) has a capacity of 31·3 watt-hours per kilogram. Greater durability is claimed than for the Fulmen type.

M. O'G.

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882. *Tests of Traction Accumulators.* (Elect. Rev. 44. pp. 6–8, 1899.)—Particulars of tests to which batteries will be subjected in the course of trials by the Automobile Club of France.

M. O'G.

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883. *Pulvis Accumulator.* (Elect. Rev. 44. p. 115, 1899.)—The only novel features in this accumulator are the employment of fine lead powder as the original active material and the use of *ambroïne* (see 1898, Abstract No. 142), a new insulating material composed of fossilised resins, asbestos, and mica, in the construction of the cells. Full details of the dimensions and weights of the various parts are given. The specific capacity and specific energy per pound of total weight are 4·26 ampere hours and 8·3 watt-hours respectively, whilst the specific weight is 124 lb. per kilowatt or 24·82 lb. per kilowatt-hour. N. L.

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884. *Accumulator Construction.* **D. Fitz-Gerald.** (Elect. Engin. 21. pp. 747–749, 1898, and 23. pp. 9–10, 42–43, 71–73, 134–135, 167–168, 277–278, 366–367, 463–464, 531–532, 1899.) —Continuation of articles on this subject. EDITOR.

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885. *Hellesen Dry Battery.* (Elect. Rev. 44. pp. 44–45, 1899.) —Curves of discharge are given, determined by the Reichsanstalt.

W. R. C.

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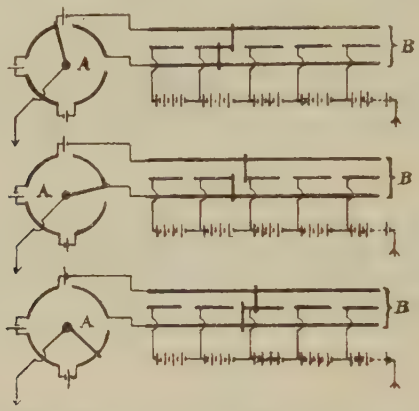
886. *Arcs and Non-arcing Metals.* **G. T. Hanchett.** (Amer. Electn. 11. pp. 16–17, 1899.)—If the vaporised substance in the arc is the greater portion of the resistance of the circuit the arc will extinguish. A non-arcing metal must therefore have very little resistance, and the break in the circuit must occur where there is a large plane surface of contact. A non-arcing metal should have as high a melting-point as possible, for in this way, even though an attenuated contact may become overheated, the amount that is volatilised will not afford as good a nucleus for the formation of an arc as will be the case with the larger volume of conducting vapour that the same heat would form from a more fusible metal. W. G. R.

887. *Lightning Arresters.* **H. E. Raymond.** (Amer. Electn. 11. pp. 15–16 and 66–68, 1899.)—An illustrated description of American lightning arresters. W. G. R.

888. *La Roche Circuit Breaker.* (Elect. Rev. N.Y. 33. p. 282, 1898.)—This is a description of a circuit breaker made by F. A. La Roche & Co., of New York, and is guaranteed to break 2,000 volt circuits without arcing at the clips. By means of a milled-head screw the circuit breaker can be adjusted to open at any point within its guaranteed high and low ampere ratings. The instruments are carefully calibrated, and are made in sizes from 15 to 500 amperes. W. G. R.

889. *Automatic Mercury Switch.* (Elekt. Runds. 16. pp. 94–95, 1898.)—A description is given of the mercury switch recently patented by Bastians. The switch is an overload switch, and in its normal position contact is maintained between the two terminals, which are mounted at the top of two vertical tubes of insulating material, by a column of mercury filling the tubes. The mercury is maintained at its proper level by a plunger, which is kept pressed down in a cylinder communicating with the two tubes, and which, by displacing the mercury, causes it to rise to the required level. The plunger is maintained in its proper position by a locking device. When the current exceeds the safe limit, the locking device is released by an electromagnet, the plunger is forced up by the mercury, which flows back into the cylinder, receding from the terminals and so breaking the circuit. Arcing is prevented by one or more glass beads, which float on the surface of the mercury in the tubes. A. H.

890. *Heath and Field Accumulator-Regulating Apparatus.* (Elect. Engin. 23. pp. 40–42, 1899.)—This is an arrangement chiefly designed for enabling the number of cables required for connecting the regulating-cells in the accumulator-room to the switchboard to be reduced to less than half that heretofore



required. It comprises two switches A, B, having their arms geared together so that the arm of A makes, say five revolutions, for each revolution of the arms of B. The connections and operation of the apparatus will be obvious from the accompanying diagrams showing successive positions of the switch arms, the fixed contacts of the switch B being developed in order to simplify the connections. Some modifications are also described. C. K. F.

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891. *Three-motor Electric Travelling Crane.* (Engineer, 87. p. 8, 1899.)—Vaughan & Sons, Manchester, have already supplied to a number of works three-motor overhead electric travellers; they have just completed one capable of lifting 50 tons. The paper describes the main features of a 20-ton traveller of similar type; this crane has a span of 45 feet, a longitudinal travel of 300 feet per minute, and a cross travel of 180 feet per minute. The three reversing switches, which are of the liquid resistance type, are contained in the cage, and are so arranged that the three movements of the traveller may be controlled either separately or simultaneously. Any risk through carelessness is removed by means of a powerful automatic brake. The brake lever is held up by an electromagnet as long as current is switched on to the motor. The act of switching off immediately automatically applies the brake. A 30 H.P. "Castle" dynamo, worked from the ordinary line of shafting, generates sufficient current for working the travelling crane, together with shop motors and arc lamps. A. S.

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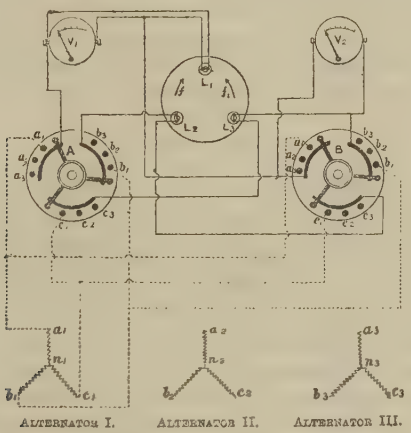
892. *Synchroniser for Three-Phase Plant.* (Elect. Rev. 44. pp. 318–319, 1899.)—The following ingenious arrangement, shown in the accompanying figure and due to Siemens and Halske, is used for synchronising three-phase generators.

A and B are two switches, each provided with as many arms (3) as there are generators, and a corresponding number of contacts. Corresponding terminals of the generators and switch contacts are indicated by the same letters. By means of the switch B, the terminals of any incoming machine may be connected to the bus bars through the synchronising lamps L_1 L_2 L_3. If the connections of the switch contacts were symmetrical, then the three lamps would at any instant be incandesced to the same extent. It will be noticed, however, that the connections are not symmetrical, the long segment contact corresponding to b_1 b_2 b_3 in switch A being in connection with the segment corresponding to c_1 c_2 c_3 in



switch B. The result is that when the *a* circuits of two machines happen to be in phase, so that—with the switches A and B in their proper positions—the lamp L_1 is extinguished, the *b* circuit of one machine is connected to *c* circuit of the other, and *vice versâ*, the lamps L_2 and L_3 being incandesced. If the machines are not running synchronously, the lamps will be extinguished consecutively, the extinction travelling round the triangle one way or the other, according as the incoming machine is running below or above the speed of synchronism. The device therefore at once indicates whether it is necessary to increase or diminish the speed of the incoming machine. The main switch is closed at the instant when L_1 is dark, and when the rate at which the extinction travels round the triangle shows that the machines are running very nearly in synchronism. The voltmeters V_1 and V_2 are provided for greater sensitiveness. A. H.

893. *Manufacture of Carbons.* **F. Jehl.** (Electrician, 42. pp. 217–219, and 301–303, 1898, and 379–380, 439–440, 612–614, 648–649, 789–790, 855–856, and 890–892, 1899.)—Continuation of articles on this subject. EDITOR.

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894. *"Fortis" Material for High Tension Lines.* **J. Reyval.** (Écl. Électr. 17. pp. 351–356, 1898.)—Illustrated account of Fortis insulator and other material. EDITOR.

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895. *Meter Practice.* **L. C. Reed.** (Amer. Electn. 11. pp. 33–35, 1899.)—A meter works for the most part at 5 to 20 per cent. of its rated capacity. It is better to risk burning up a meter than to instal a large one which would be inaccurate on the usual load. All meter repairs, except the actual making of parts, should be done at the station in a specially fitted repair shop. This is much the cheapest plan. E. H. C.-H.

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896. *Richard Electric Meter.* (Electricien, 16. pp. 267–268, 1898.)—In this meter the clockwork movement is driven as follows: The ordinary driving barrel is replaced by a ratchet-wheel turned by a spiral spring acting through a pivoted T-shaped lever, one arm of which bears a pawl engaging with the ratchet-wheel, another arm the armature of a shunt electromagnet, and the third arm an adjustable set-screw actuating the make-and-break of the electromagnet circuit. The make-and-break comprises two spring-pressed pivoted bars arranged at right angles to each other; one of the contacts is mounted on one of these bars (the horizontal one), the other contact being stationary and arranged opposite to it. The horizontal bar bearing the contact is arranged to be held away from the fixed contact by resting on the end of the other or vertical bar whilst the driving spring is extended and the pawl is turning the ratchet-wheel, but when the spring has drawn the pawl to the end of its travel, *e.g.*, an angle corresponding to one tooth, the set-screw on the third arm of the T-shaped lever pushes the vertical bar from beneath the horizontal bar, which descends and allows the circuit to be completed through the electromagnet. The armature is then attracted, the driving spring extended and, by means of a second adjustable set-screw on the T-shaped lever, the horizontal bar is raised and the circuit through the electromagnet interrupted, the horizontal bar being again retained in its raised position by the vertical bar which moves beneath it under the action of its spring. These motions are reproduced every twenty seconds.
C. K. F.

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897. *Cauderay Multiple Electric Meter.* **M. Aliamet.** (Électricien, 16. pp. 395–400, 1898; British Patent, No. 7,877 of 1897.)—This meter comprises a clock the hands of which integrate the hours and decimals thereof. The movement of the wheels of this clock is produced by a balance-wheel controlled by a special spring, the motion of which is maintained electrically. The integrator, actuated periodically by the clock, moves proportionately to the number of circuits supplied with current at the station, the motion of each taking place independently, *e.g.*, if the lamps at the station are divided into two circuits, the integrator will move twice as fast when the two circuits are supplied with current, as when only one is supplied. The balance-wheel arbor bears an armature which is intermittently attracted by two oppositely arranged electromagnets, the circuits of which are made and broken by a spring-controlled pivoted finger engaging a notched cam on the balance-wheel arbor. The said arbor, by means of a spring pawl and a ratchet-wheel, drives a shaft having a series of pins arranged at equal distances apart along at equal angles apart around it. Parallel to this pin-shaft is mounted a spring-controlled frame capable of oscillating through a limited distance and bearing a pawl which moves a ratchet-wheel on the integrator train one tooth forward at each oscillation of the frame. By the side of each pin, is arranged one end of a pivoted lever controlled by an electromagnet in one of the circuits to be supplied with current, and adapted, when the electromagnet is energised, to move the lever between the corresponding pin and the oscillating frame so that the said pin will press the end of the lever against the frame and cause it to oscillate. By these means it will be seen that, in each revolution of the pin-shaft, the integrating train will be actuated the same number of times as there are electromagnets energised. The original paper is illustrated by a number of clear drawings. C. K. F.

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898. *Control of Distant Mechanism by Electricity.* (Elect. Rev. N.Y., 33, p. 298, pp. 305–308, p. 312, 1898.)—These articles give the full text of a recent patent in which Tesla sets forth his proposed method of steering and controlling ships by the use either of Hertz waves or of earth conduction. The coherer-principle is the basis of most of the devices. Coherers, or their equivalents, govern the various relay-circuits which control the mechanism of the propelling and steering gear. R. A.

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899. *Electrical Survey in New York City.* **A. A. Knudson.** (Amer. Instit. Elect. Engin. 15. pp. 653–672, 1898.)—Details are given, with plans and tables, of an electrical survey made in New York City, U.S.A. It is shown that no appreciable leakage occurred from the open conduit tramway, in which an insulated return is used; but a steady potential difference of $\frac{1}{30}$ to $\frac{1}{10}$ volt between rails and earth was traced to the electric lighting systems

and a variable P.D. to an overhead trolley line. The tram rails were in general positive to water and gas-pipes, the P.D. ranging from $\frac{1}{5}$ to 2 volts. At a terminus of the trolley line this P.D. increased to 10 volts, and here the rails were excessively corroded. The Brooklyn suspension bridge was generally 2 to 3 volts positive to earth: the probable effect of the resulting current upon the cables and anchor-plates is discussed, but not considered important. It is shown, however, that a very small P.D. may cause serious injury to pipes, &c., and that cast iron is by no means exempt. A. H. A.

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900. *Utilising Capacity of Cables.* **H. Andriessen.** (Elect. Engin. 23. pp. 10–11, 1899.)—To obviate the lag of current on lighting circuits with inductive loads, concentric cables are cross-connected at the junction points: the inner to the outer, and the outer to the inner wire. The effect of this is to increase the capacity between the wires. In a given example this amounted to 65 per cent. The potential difference between each conductor and the earth is equal to half the E.M.F. of the dynamos. M. O'G.

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901. *Hot Pressing of Cloth.* **C. Mouchel.** (Electricien, 17. pp. 58–59, 1899.)—German silver wires are imbedded in asbestos laid up between two sheets of card (2 to 4 millimetres thick) the two terminals of the wire being brought to opposite corners of the cards under a strengthening metallic corner. The whole is then used between the folds of the cloth to be pressed, electrical contact being made with the projecting corners by means of clips. Perfect control of temperature, economy of coal, and low first cost are claimed. The system is due to Chedville. M. O'G.

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902. *Electric Vehicles and their Relation to Central Stations.* **H. M. Maxim.** (Elect. World, 33. pp. 116–117, 1899.)—In this article the author urges suppliers of current to give every facility for charging accumulators from their mains as by so doing they will forward the more general adoption of motor vehicles and cultivate what will eventually become an important addition to their customers. For the information of supply companies and accumulator manufacturers it is stated that at present accumulators for vehicles should show a capacity of from 3·5 to 4 ampere hours per pound of cell complete with lugs, jar, &c., at a discharge rate of not less that 1·3 amperes per pound of complete cell. It must be possible to increase this rate to 4 or 5 amperes per pound of cell for short periods, without injury, and to effect complete charge in three hours, or thereabouts. In France several firms are engaged in the business of letting out or caring for vehicles fitted with high capacity batteries, for which there is a great demand. Motor cars should be of great use for such purposes as parcels' delivery, &c. W. G. R.

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903. *Parvillée Electric Heating Apparatus.* **J. Reyval.** (Écl. Électr., 18. pp. 138–143, 1899; U.S. Pat., No. 658,450.)—In this apparatus the heating resistance is formed of a substance capable of being heated in the open air. This substance is made by adding to a metallic powder (preferably nickel) a ceramic product (*e.g.*, a mixture of quartz, kaolin, and a flux), grinding the whole together, compressing it in rectangular moulds at a pressure of 2,000 kilos. per sq. cm., and then drying and baking it in a furnace at a temperature of 1,350° C. A plate 5 cm. × 3 cm. × 1 cm. has a resistance of 100 ohms, and will stand heating to a bright red heat for 1,400 hours without deterioration. These resistances are held in copper clips mounted on flexible strips, so as to permit expansion. The selling price of a resistance absorbing 5 A. at 110 V. will not exceed 3f. Several forms of stove employing these resistances are illustrated in the original paper. C. K. F.

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904. *Electric Power in Mining.* **J. McGhie.** (Cassier, 15. pp. 37–48, 1898.)—This is a well-illustrated article on electric mining machinery, chiefly American. R. B. R.

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905. *Electrically Operated Drawbridge.* **W. Kidde.** (Electricity, N.Y. 15. p. 295, 1898.)—Since February, 1898, a 450-ton drawbridge over the Passaic River at Newark, N.Y., has been successfully operated electrically. The contractors were required to furnish power (from a 500 volt direct circuit) which would open or close the bridge in thirty seconds, this power not to be available until the wedges and locking device had been withdrawn; also the wedging and closing devices must be automatically cut off, so that they could not be used till the bridge is closed. These conditions have been successfully met, and the bridge operated by three unskilled men on their regular trips. Two cables are carried under the bed of the river up through the centre pin of the bridge into a contact commutator under the roadway. The commutator has two parts, the lower consisting of a copper ring and central disc attached to, but insulated from, the stationary centre bridge pin. Over this is the heavy circular part which moves with the draw and carries on a diameter three insulated contact shoes, two of which are respectively held in contact with the ring and disc on the stationary part, and thus establish a lead and return to the motor-room above. The third shoe only touches the lower ring when the bridge is closed, and breaks contact by means of quick acting springs directly the bridge begins to open; the circuit through this shoe and the centre disc drives the motor when operating the wedge shaft. The motor-room contains one motor with extended shaft to carry several clutches and gears. The first is the spur-wheel driving the line shaft which operates the bridge, and is mounted on a friction clutch. Another clutch is attached

by a sprocket-wheel and chain to the shaft for the locking devices and wedges. These two clutches are worked alternatively by a common lever, which also makes the requisite electrical connections. In mid-position neither clutch is in use.

The position of the wedges is indicated on a disc by a mechanism which also automatically interposes a latch bar in the arc of the clutch lever, so that the bridge cannot be turned until the wedges have been withdrawn. An air-pump, connected to the motor-shaft by iron link belting, maintains 40 lb. pressure in a receiver for a signal whistle. The speed and direction of rotation of the motor are governed by a reversible controller, which regulates the speed with the different loads due to operating pump, wedges, and bridge. This controller and the clutch-lever are worked from a position overlooking the river. The drawbridge structure is 720 feet long, while the draw proper is 227 feet in length and 67 feet wide. The moving span weighs 450 tons. The author suggests that the score of bridges close to one another over the Harlem River in N.Y. City should be electrically operated from one central plant radiating power which would precede a ship in its passage through the successive draws. E. H. C.-H.

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906. *Electricity in Open Hearth Steel Works.* (Eng. News, 40. pp. 194–197, 1898.)—The author describes how various mills are operated with electrical tables and cranes. For example, a reversal mill handles 24″ I–beams, and is served by a single attendant by a combined hydraulic and Ward-Leonard electrical table. The advantage of the rolling mill equipped with these tables was found to be that the metal could be delivered at a speed of 1,000 feet per minute, and regularly rolled into 150 feet lengths or longer. The plant is described in some detail. M. O'G.

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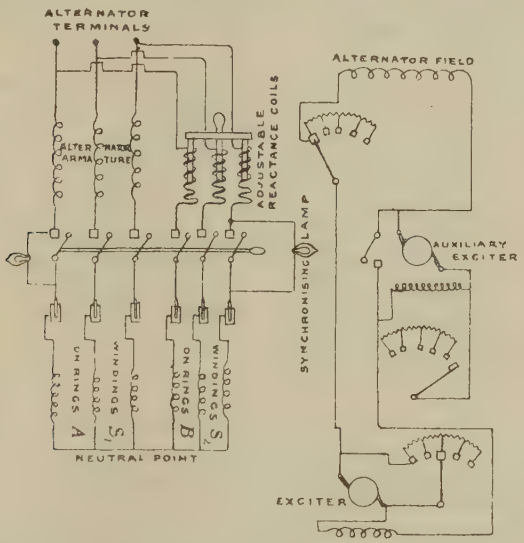
907. *Electric Lifts for New Brighton Eiffel Tower.* (Engineer, 87. pp. 3–5, 1899.)—The whole of the lifting plant at the New Brighton Tower is operated by electric motors, the contractors of which are Easton, Anderson, and Goolden. Two lifts for passengers and one for goods run from the base to a platform 80 feet high. There are two lifts in the spire conveying passengers from the 80 feet level to the 384 feet level. The galleries above the 384 feet level are reached by a staircase. In these lifts the winding drum is done away with, its place being taken by a simple eight-grooved rope pulley and a crossover pulley. The eight-grooved pulley is driven by means of a wheel and worm enclosed in a cast iron casing with suitable thrust block. The motor shaft carries a brake drum, acted upon by a magnetic brake which automatically holds the gear, except when the motor magnets are energised and lifting or lowering is taking place. The balance weights have a stroke of one-fourth the passenger cages. The arrangement of the guide pulleys is described, and the whole arrangement of the gear illustrated by numerous drawings. A. S.

GENERATORS, MOTORS, AND TRANSFORMERS.

908. *Compounding Alternators.* **M. Leblanc.** (Écl. Électr. 17. pp. 425–432, 473–482, 509–512, and 547–551, 1898.)—The author first describes the arrangement referred to in Abstract No. 620 (1899), and then proceeds to further develop the theory. The result arrived at indicates that there should be no difficulty in constructing the exciter in such a manner as to secure absolute constancy of P.D. between the alternator terminals with varying load. The question of parallel running is next discussed, and the author shows that by the use of his exciter an alternator with enormous armature reaction may still be expected to synchronise better than machines of ordinary construction. Since the exciter



has to run synchronously with the alternator, the simplest plan is to mount the rotors of the two machines on the same shaft, and provide the fields with the same number of poles. This method is not, however, feasible in the case of very large slow-speed machines, or where it is desired to provide previously constructed machines with the new form of exciter. Reduction gearing might be used; but the following method would probably be more convenient. In addition to the winding, which is designed to counteract armature reaction, and which is traversed by the armature current of the exciter, another similar winding is provided, but arranged so that when it is traversed by the armature current it gives rise to poles in the field rings which lie between the poles due to the former winding. The field due to this additional winding causes the armature to run in synchronism with the

alternator; the exciter, in fact, forming a combination of a synchronous motor driven by the alternator with a continuous-current dynamo exciting it.

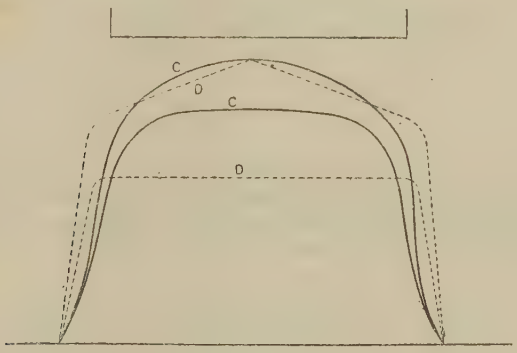
Drawings of a six-pole exciter constructed on this plan for a three-phaser are given, and the arrangement of connections required for starting it is shown in the accompanying sketch. An auxiliary series-wound dynamo is used at starting to excite the alternator, and to run the exciter, which behaves like a continuous-current motor, up to the speed of synchronism. The alternating-current windings of the exciter armature are next connected to the alternator, when the exciter will run as a synchronous motor, and furnish a continuous current. Lastly, the auxiliary dynamo is thrown out of circuit. An alternator provided with such an exciter requires no attention, for when once the necessary preliminary adjustments have been made by means of the impedance coils (see diagram) and the rheostat in the field circuit, it will be self-regulating.

In order to test the soundness of his theoretical deductions, the author gives an account of some interesting experiments carried out with a 60-kilowatt two-phaser provided with an exciter of the form described above. In this case the rotors of the two machines were mounted on a common shaft. Preliminary experiments showed that the exciting current required to produce the normal voltage on open circuit was 28 amperes, whereas the exciting current required to maintain the full-load current through the short-circuited armature when running at normal speed was 91 amperes! Notwithstanding this enormous armature reaction, and without any preliminary adjustments, the alternator gave the following results when running under load:—

Revs. per min.		792	794	789	794	786	770	772	780	792	770	788	762	754
Circuit I.	Idle current	0	74·8	76	76·5	79	80	79	80	79	79	77·5	77·5	74
	Load current	0	0	63	75	85	106	125	120	152	165	192	223	240
Circuit II.	Idle current	0	74·5	75	76·5	79	80	79	80	79	79	77·5	77·5	74
	Load current	0	0	63	73	73	103	122	120	155	155	205	228	250
Terminal P.D.		92	114	116	118	114·5	116·5	118·5	115·5	110·5	114	110	104	96

The total flow of current per cm. length of the rotor circumference amounted in this alternator to 225 amperes, as against 70 in alternators of usual construction; the output of the machine is therefore about 3·2 times that of an alternator of ordinary design having the same dimensions. Some further experiments were tried, in order to test the behaviour of the machine when running in parallel with others: it was found impossible to throw it out of synchronism. A. H.

909. *Magnetic Flux in Dynamo Air-gaps.* **W. E. Goldsborough.** (Amer. Instit. Elect. Engin. 15. pp. 637–652, 1898.) —If the armature surface is taken as a plane extending indefinitely to right and left, and the pole-piece is a rectangular block with square corners, the number of lines of force which pass between any pair of points on the pole-piece and armature respectively will be inversely proportional to the distance between them measured in air. And the strength of the magnetic field at the surface of the armature at any point will be proportional to the sum of the reciprocals of the distances of that point from all the points on the perimeter of the pole-piece made by a section-plane passing through that point. The figure shows two sets of curves for a bipolar Jenney dynamo; the C curves represent the distribution of flux calculated by the author's method, and the D curves the distribution usually assumed. The ordinates of the D



curves are inversely proportional to the length of the air-gap. The upper set of curves are taken with a double air-gap of 1·25 in. at the centre of the pole-face and 1·52 under the leading and trailing pole-tips; in this case the results obtained by exploring the air-gap field by the pilot brush method agree much more closely with the C curve than with the D curve. The lower curves are taken with an air-gap of 1·98 at all points. In this case the C curve represents a very much stronger field than the D curve. The ratio of our mean ordinates of the C curve is 0·899, whereas the ratio for the D curves is 0·699. We see, therefore, that the rate at which the strength of the air-gap field decreases as the length of the air-gap is increased, falls far short of being inversely proportional to the rate of increase in the mean length of the air-gap, supposing that the C curves represent the true condition.

R. B. R.

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910. *Electric Generators.* **H. F. Parshall** and **H. M. Hobart.** (Engineering, 67. pp. 41–44, 100–101, 374, 475–477,

and 537–540, 1899.)—An illustrated series of articles on various electric generators, and notes on design. EDITOR.

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911. *Alternating-Current Machinery.* **E. J. Houston** and **A. E. Kennelly.** (Elect. World, 32. pp. 627–628, 684–686, 1898, and 33. pp. 175–177, 1899.)—Description of apparatus. EDITOR.

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912. *Monophase Asynchronous Motors.* **G. B. Maffiotti** and **F. Pescetto.** (Ecl. Électr. 18. pp. 145–148, 1899; also Atti della Associazione elettrotechnica Italiana, vol. i. p. 55.)—An expression for the torque Y in a monophase induction motor is—

$$Y = 2A\zeta x \cdot \frac{1 - x^2 - \zeta^2}{\{\zeta^2 + (1-x)^2\}\{\zeta^2 + (1+x)^2\}} \qquad (1)$$

where

$$A = \frac{NB^2S}{4L}; \quad x = \frac{m}{n}; \quad \zeta = \frac{r}{2\pi nL}$$

m being the frequency of the stator currents, n that of the rotor currents, N the number of convolutions on the rotor, S the area of the magnetic circuit, B the maximum induction, r the resistance, and L the self-induction of one convolution of the rotor coils.

The envelope of the curves given by (1) regarding ζ as the variable parameter is obtained by eliminating ζ between (1) and the equation—

$$\frac{dY}{d\zeta} = 0$$

and is found to be—

$$(\zeta^2 + 1 - x^2)\{\zeta^4 - 2(3 - x^2)\zeta^2 + (1 - x^2)^2\} = 0$$

and since x is less than unity, this reduces to—

$$\zeta^4 - 2(3 - x^2)\zeta^2 + (1 - x^2)^2 = 0$$

or—

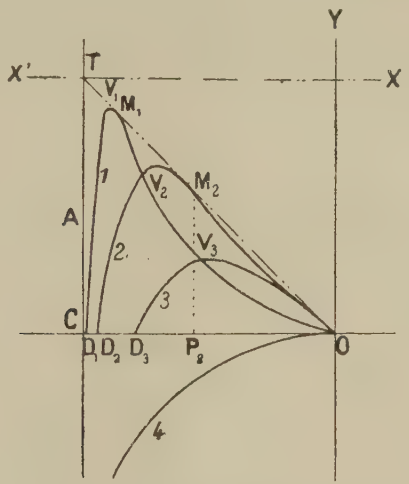
$$\zeta = \sqrt{2 - x^2} - 1 \qquad (2)$$

On substituting this value of ζ in equation (1) the expression becomes—

$$Y = Ax$$

which is a straight line through the origin. This is the locus of the extremities of ordinates representing the maximum values of Y for a given value of the slip when variable resistance is placed in the rotor circuit.

The curves in the figure represent the couple Y as a function of the slip for different values of ζ. If ζ is zero, the curve is represented by the straight lines OT and TC. When the point of



contact of the curve with OT is at O, that is for $x=0$, the value of the resistance corresponding to the greatest torque is—

$$\zeta=\frac{r}{2\pi n\mathrm{L}}=\sqrt{2}-1$$

or— $$r=0{\cdot}414\times 2\pi n\mathrm{L}$$

This value of ζ varies a little with the load, but is found to be almost constant for varying loads. W. G. R.

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913. *Transformers.* (Supplement to Engineer, pp. ii–iv. Nov. 25, 1898.)—In this article, which is quite of a practical nature, the following requisites of a good transformer are emphasised:—

1. Low magnetising current. 2. No magnetic leakage. 3. Low copper loss. 4. High power factor on no load. 5. Iron carefully laminated, selected, and annealed. 6. Thorough ventilation of the iron. 7. Thorough ventilation of the copper. 8. No eddy currents in the copper windings. 9. Low temperature of both iron and coils. 10. Simplicity of construction. 11. Strength in design and construction, so that it may withstand the rough handling to which it will inevitably be subjected. 12. The power to withstand a test pressure between primary and secondary, and between primary and iron, of double that at which the transformer is to be worked.

Illustrations and criticisms are given of Berry, Mordey, Westinghouse, and Kapp transformers. The Walton automatic cut-in switch is also described. W. G. R.

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914. *Single-Phase Motors.* (West. Electn. 24. pp 30–32, 1899.) —This is an illustrated description of the monophase induction motors made by the Wagner Electrical Manufacturing Company of St. Louis. The motors, which are of all sizes from 1 to 20 H.P. are constructed for any impressed E.M.F., between 100 and 500 volts. Details of these motors are given in the following tables:—

MOTORS FOR 60 CYCLES PER SECOND.

Horse-Power.	Full Load Current at 104 Volts.	Full Load Efficiency.	Watts at Light Load.	Speed in Revs. per Minute.	Approximate Shipping Weight in lbs.
1	11	75	150	1750	275
2	22	78	240	1750	400
3	32	79	300	1750	550
5	55	80	450	1750	800
7·5	82	83	550	1750	950
10	110	84	800	1753	1050
15	160	86	1000	1150	1600

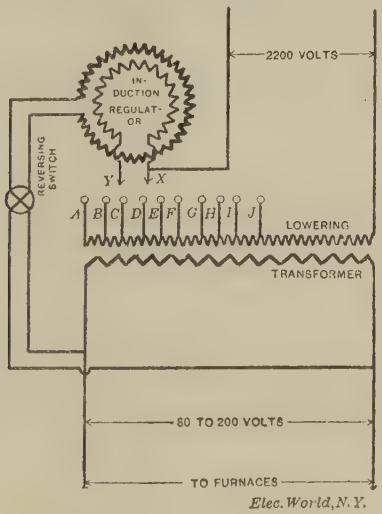
MOTORS FOR 133 CYCLES PER SECOND.

Horse-Power.	Full Load Current at 104 Volts.	Full Load Efficiency.	Watts at Light Load.	Speed in Revs. per Minute.	Approximate Shipping Weight in lbs.
0·75	10	60	135	1950	275
1·5	20	68	200	1950	400
2	25	70	240	1950	550
3·5	47	71	450	1950	800
5	70	73	500	1950	950
7·5	110	75	850	1550	1050
10	135	78	900	1550	1600

W. G. R.

915. *Induction Motor Diagrams.* **C. C. Hawkins.** (Electrician, 42. pp. 467–468, 528–529, and 610–612, 1899.)—This is a series of articles dealing with the theory of induction motors by means of clock diagrams. W. G. R.

916. *Transformer Equipment of Carborundum Company.* **J. S. Peck.** (Elect. World, 33. pp. 16–18, 1899.)—In the manufacture of carborundum it is extremely important to maintain the power supplied to the surface as constant as possible. But since the resistance diminishes as the furnace gets heated up, some regulating device for varying the P.D. across the furnace must be provided. The ordinary method of cutting out or introducing turns in the primary or secondary of the transformer is not suitable, as it is a step-by-step method, and does not give sufficiently close regulation. In the old Westinghouse plant supplied to the Carborundum Company an induction regulator consisting of a transformer with movable circuits was employed, the E.M.F. being capable of gradual variation by changing the relative positions of the circuits. Such an induction



Elec. World, N. Y.

regulator is, on account of the large output required, very expensive, and its power-factor is low. In the new plant arrangements have been provided for varying the number of turns in the primary, and the change of E.M.F. in passing from one section of the primary winding to another is rendered continuous by the action of a small induction regulator, whose primary circuit is connected, through a reversing switch, across the secondary terminals of the transformer, while its secondary circuit is in series with the primary mains. The connections are shown in the accompanying sketch, and the action is as follows: Let Y be in connection with J, and let the regulator E.M.F. act in the direction of the main E.M.F. Then the secondary E.M.F. has its highest value. By turning the hand-wheel of the regulator so as to reduce the E.M.F., the following series of operations is carried out: the regulator is rotated, its E.M.F.

gradually diminishing, vanishing, and reappearing with reversal of sign, until the maximum negative value is reached; at this point X is connected to I, Y disconnected from J, the primary of the regulator reversed, Y advanced to H, and X disconnected; and so on. Another important feature of the new plant is the method of cooling the oil in which the transformer and regulator are immersed; this is accomplished by means of a few turns of copper tubing placed just below the surface of the oil, and connected to the water-mains. The cost of the pump, motor, and special cooling tank used in the older plant is thereby saved.

A. H.

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917. *Rectification of Alternate Currents.* (Elekt. Runds. 16. pp. 73–74, 1898.)—A description of the device recently patented by C. Pollak, the principle of which is as follows: A cylindrical vessel of insulating material is divided into two compartments by a partition (normal to the axis of the vessel) consisting of three perforated insulating discs, the middle disc being mounted on an axle which is driven by a synchronous motor, while the two outer discs are fixed, but capable of adjustment relatively to each other by a motion of rotation. The vessel is filled with an electrolyte, and an electrode is placed in each compartment. The cell is introduced into the circuit which is to receive the rectified currents. As the middle disc rotates it periodically establishes and cuts off communication between the two compartments through the perforations of the discs, the perforations being so spaced that with synchronous rotation of the disc communication is established during one half-wave of current, and cut off during the next half-wave. By suitably displacing the two fixed discs relatively to each other, any desired portion of the half-wave may be utilised. A. H.

POWER DISTRIBUTION, TRACTION, AND LIGHTING.

918. *Design of Secondary Circuits in Alternating Plants.* **G. L. Thayer.** (Elect. World, 33. pp. 118–120, 1899.)—In the design of circuits for alternating work, capacity and skin effect may be neglected. Capacity only assumes importance in long distance lines, and the influence of skin effect does not exceed 2 per cent. in 0000 copper at 125 cycles, and less in smaller sizes.

The line of improvement must lie in the direction of better regulation and increased efficiency of distribution. This leads to the general adoption of large transformers to diminish the light load losses and the use of high efficiency lamps. For lamps taking only 3·1 watts per candle-power the regulation must be brought to within 2 per cent.

As regards frequency, for a lighting circuit only 125 periods is suitable, but if motors are also to be supplied it is better to change to 60 cycles.

It is possible to use transformers too large for the most economical results, since there is a point different on every station at which the interest and depreciation on the copper is greater than the saving in core losses. W. G. R.

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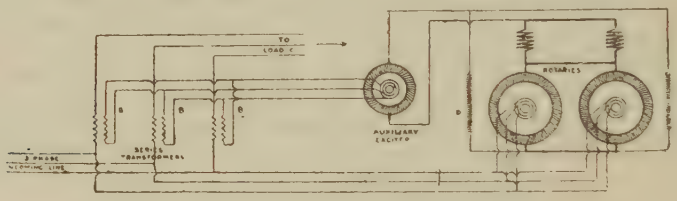
919. *Regulation by Leading and Lagging Currents.* (Journal of Electricity, 7. pp. 28–29, 1899.)—This is a description of the regulating devices used in the Mechanicville-Schenectady transmission plant, in which large lagging currents are produced by induction motors. The system is practically compounded for constant potential at the direct current terminals of the rotaries. The compounding is effected in the transmission line, which consists of three No. 000 wires all mounted on one cross arm. The rotaries at the receiving end are compound wound with a heavy series winding, the ampere turns of the two field windings being so proportioned that on no load the excitation of the shunt winding is sufficient to generate at synchronous speed a back electromotive force sufficient to choke back the impressed alternating current waves. The result is that wattless currents lagging behind the impressed E.M.F. enter the rotary armature and automatically increase the field excitation to a proper value. These lagging currents react upon the self-induction of the line. As the load rises the action of the series coils on the rotaries asserts itself and the wattless lagging currents are diminished.

This arrangement would be sufficient for proper regulation but for the interference of the load taken by some synchronous motors. Any increase of their load increases the ohmic drop in the line without any compensating effect in the wattless currents

taken by the rotaries. Any variation also of the phase relations of the synchronous motor load will still further disturb the proper combination of ohmic and induction drop on the line which should be independent of the load. To make the rotaries take currents which shall effect this the following system has been devised :—

The rotary shunt fields, as shown at DD in the figure, are excited from a separate direct current bus bar which is fed with current from the main bus bar through an auxiliary exciter A. This auxiliary exciter serves to raise the voltage across the rotary fields, and is driven by an alternating current synchronous motor of the same number of poles, thus keeping its armature in step with the alternating system. It has no field-exciting winding, but its armature is fitted with three collecting rings into which the alternating current may be introduced from the secondaries of three small series transformers shown at B, the primaries of which are inserted in the lines feeding the synchronous motor C,



and any other loads supplied over the same transmission line, with the exception of the rotaries. The armature of the auxiliary exciter is coupled to the synchronous motor at such an angle that the currents introduced from these series transformers, when the load passing through their primaries is of unity power factor, tend to set up a field of force in the magnetic circuit of the auxiliary exciter, and build up a direct current voltage across its brushes ; thus the greater the load on the system, the greater is the boosting action of the machine A, and the greater is the voltage across the field windings, D, of the rotaries. Further, if the load on the system, C, becomes lagging, tending to still further increase the drop on the line, the currents entering the armature of the machine A lag also and excite to a greater extent the magnetic circuit of that machine, causing a greater current in the rotaries which causes the armatures of the rotaries to take leading currents and balance the lagging current of the load C.

In this way the load on the system, C, can vary in magnitude or phase relation by any amount within limits without affecting the voltage relation at the direct current terminals of the rotaries. W. G. R.

920. *Polyphase Distributing Systems.* **T. Marcher.** (Elekt. Runds. 16. pp. 53–56, and 66–68, 1898.)—The paper contains an account of the different systems of arranging transformers and mains for a combined supply of light and power from the same network. Some data regarding the regulating properties of an arrangement patented by the author are given. A. H.

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921. *Electric Transmission in Mining.* **W. B. Esson.** (Instit. Civ. Engin. Proc. 135. pp. 54–74, 1899. Discussion, pp. 75–113, 1899.)—Chiefly a description of a two-phase transmission at the Sheba Company's mines, Barberton, Transvaal. Originally 162 H.P. were required at the mine, 100 H.P. being for a 60-stamp mill. With a 20-stamp mill the working costs for fuel and transport over three miles were £1 12s. 6d. per ton of ore milled, as against 1s. 8d. per ton with the present 60-stamp mill electrically worked at the mine. Two-phase current was chosen as giving the best regulation for lighting. Current is generated at 3,300 volts, and transformed to 100 at the mine. A 30 in. and a 25 in. "Victor" turbine on a 32 feet head give 396 B.H.P. at about 250 r.p.m. "Snow" governors act directly on the turbine gates, but cannot control speed under large fluctuations of load. The Kapp alternators have stationary armatures and rotary field-magnets at 400 r.p.m. excited by a single coil. Frequency 53·3. Switchboards are of polished teak, because of danger in transporting slate: with micanite washers and bushes the insulation is very high. When paralleling alternators the incoming machine is plugged on to the synchronising bars, and when the hot-wire voltmeters indicate approximate synchronism it is thrown into main circuit by closing, through a large choking coil, a path between the synchronising bars and the main bus bars. The choking coil prevents a large rush of current due to phase difference, though it allows sufficient current to pass to pull the new machine into step. The cables are concentric, laid underground to avoid lightning troubles and the drop due to self-induction if they were overhead. The transformers are of single-phase pattern, one on each phase. Efficiency at light loads is of little importance compared with good regulating qualities, efficiency at full load and capability of running continuously at full load. If special two-phase transformers were used, 50 per cent. would have to be kept as spare, whereas 25 per cent. suffices with single-phase. Immersed in resin-oil in cast-iron cases, the insulation failed. Convection currents appeared to circulate any moisture in a finely divided state. The two-phase motors have rotary fields; two of 50 H.P. run at 640 r.p.m., and three of 15 H.P. at 800 r.p.m. The lines of force pass from the stator into the rotor, the field being thus formed of a number of closed magnetic circuits moving circumferentially with a certain velocity. As the field rotates the copper rods of the motor are cut by lines of

force, and currents are induced in them which, tending to stop the rotation of the field, compel the rotor to follow its movement. There must be relative movement or slip between the rotary field and the rotor. In running, the slip adjusts itself so as to allow such currents to be generated in the rotor bars as will give the necessary torque for the particular load on the motor. When fully loaded the slip is about 3 per cent. for the 50 H.P. motors, and 3½ per cent. for the 15 H.P.

At starting the slip is equivalent to the speed of the field, the motor being momentarily at rest. Consequently a large current passes, which in sizes above 10 H.P. is objectionable. In the larger sizes the rotor windings are therefore not short-circuited, but are arranged in three groups, attached star-wise to a common junction, with their free ends brought out to three insulated rings on the shaft. These rings connect with three resistances, also connected star-wise, and provided with a regulating switch working on all three branches simultaneously. Besides preventing excessive current at starting, this resistance increases the torque. The motor will thus start against full running torque without taking more than normal current, or against double torque with double the current. Owing to currents in the rotor weakening the resultant field, when a certain load is reached increased current actually produces a diminished torque, and any further increase of load will bring the motor to rest. The 50 H.P. motors would not work beyond 65 H.P.; their no-load current is 70 amperes per phase at 100 volts, though the true watts are only 1,400. The no-load current is 28 per cent. of the full-load current. But while the power-factor is only 0·1 at no load, at full load it rises to 0·8, and the efficiency is then 92 per cent.

Compressors to be electrically driven should have at least two cylinders with their cranks at right angles. Three-throw single-acting pumps are the most suitable for electric driving.

In the *Discussion* the author stated that the central-bobbin field-magnet had been found unsuitable for induction load, and had given place to radial poles wound separately. **W. H. Preece** said that cables 3 feet underground were as liable to disturbance from lightning as when on poles. **W. E. Ayrton** pointed out that the introduction of resistance at starting reduced the time constant and brought the currents more into phase, so that the large currents in the stator more nearly coincided with the large currents in the rotor. **G. Forbes's** experience with oil insulation in the Niagara transformers had been quite satisfactory. **W. H. Ravenshaw** pointed out the danger in a two-phase motor stopping when hauling up a steep incline. **A. Steiger** discussed turbine governors. In Switzerland they now govern within 4 per cent. when 25 per cent. of full load is taken off, and with 8 per cent. when full load is switched off. **A. Siemens** said the great drawback to three-phase induction motors was that they gave their best efficiency at one particular speed. **G. Kapp** had adopted the two-phase system at Sheba in preference to three-phase, in spite

of the latter requiring 25 per cent. less copper in the line, because (1) triple cables were not made twisted but only concentric, which would be too difficult for local jointers, (2) the less the windings overlap (*i.e.*, the fewer the phases) the easier are repairs effected.

Oil insulation is quite satisfactory for transformers, provided proper oil is used with a head over the transformer case. Threads of moisture only occur at the surface of the oil. E. H. C.-H.

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922. *Electrical Transmission in Workshops.* (Supplement to Engineer, pp. ix–xiv, November 25, 1898.)—The Broadheath Works of the Linotype Company, near Manchester, are described; details are given of the generating and distributing plant, with curves showing the steady nature of the load. The machine tools, most of which are small, are grouped and belted to lengths of shafting driven by either 5 or 10 H.P. motors. Amongst other details of tests, it is stated that a $2\frac{1}{4}$ in. shaft, 93 feet long in ten bearings, required 0·42 H.P. at 200 revs. per minute, or 0·042 H.P. per bearing; a similar shaft 130 feet long absorbed 0·052 H.P. per bearing. The power output is about 75 kilowatts; the commercial efficiency of the generating plant is 80 per cent., and the running costs amount to 0·94d. per B.T.U. Lighting and power are supplied from the same plant without inconvenience.

A. H. A.

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923. *San Gabriel Los Angeles Transmission Plant.* **G. P. Low.** (Journal of Electricity, 6. pp. 81–103, 1898.)—These works derive their power from the San Gabriel river in California. The intake is situated about six miles above the power house; in summer the river appears to be nearly dry owing to the greater part of the water passing through the loose river-bed and flowing in it. To utilise this water an underground concrete dam has been constructed: this collects the underground water, which is passed into the conduit. The conduit consists principally of concrete lined tunnel and wood pipe, the latter being 48″ internal diameter built up of longitudinal wooden staves bound together with iron hoops, the pipes are laid 10 feet below the hydraulic gradient of the conduit, and are therefore always charged with water.

Four sets of turbines and generators are installed, each set yielding 550 H.P. The turbines are of the Tutthill impulse type, with two bucket-wheels on a horizontal shaft; they run at 430 revs. per min. under a head of 400 feet. The alternators are coupled direct to the turbines, and give two-phase currents at 500 volts.

The current is transformed up to 17,000 volts, and transmitted 23 miles along two three-wire circuits carried by poles; the wires are arranged in two equilateral triangles with 30″ sides. The dis-

tribution is very complicated, the station working in parallel with three other sources of supply by means of transformers, motor generators, &c. Current is supplied in Los Angeles by the following systems: (1) Single-phase 2,400 volt service for outlying districts; (2) two-phase 2,400 volt power service; (3) 500 volt direct current power service; (4) 220 volt direct current three-wire service; these different services, combined with the fact that currents reach the sub station from four different sources at varying voltages, &c., make the switchboard arrangements exceedingly interesting.

The article contains a very detailed description of the work, and is fully illustrated. M. G. W.

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924. *Plant at Niagara.* **J. E. Woodbridge.** (Elect. World, 33. pp. 3–15, 1899.)—An illustrated description of the plant at Niagara Falls. W. R. C.

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925. *Accumulator at San Francisco Edison Station.* **G. P. Low.** (Journal of Electricity, 6. pp. 25–33, 1898.)—The battery consists of two sets of chloride cells, each of about $1\frac{1}{2}$ tons weight, discharging at a maximum rate of 3,500 amperes for one hour. The chief point of interest is the arrangement for cutting the regulating cells in or out as required. The mechanism is placed near the battery-room instead of on the switchboard, to avoid the cost of connections, and is worked by means of a motor. There are special devices for indicating the positions of the regulating switches. W. R. C.

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926. *New Union Station: Boston.* (Electricity, N.Y. 16. pp. 19–21, 1899.)—Four separate railways enter Boston from the south. Three of these have been absorbed by the New York, New Haven, and Hartford Railroad Co., which has combined with the fourth, the Boston and Albany Co., to build a new Union Station, replacing the three old ones. Twenty-five acres of land, costing over $9,000,000, were purchased, bordering on a harbour inlet. The most interesting feature is a loop-shaped subway over which the suburban trains will be worked electrically on the third rail system, without shunting. Seven hundred and ten trains use the station each day. Electric lifts are used. A novelty is the provision of distinct platforms for luggage, to avoid hampering the passenger platforms. The total cost of buildings and land was $14,000,000. E. H. C.-H.

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927. *Lausanne Tramways.* **C. du Riche Preller.** (Engineering, 66. pp. 769–772, 1898.)—There is over 1,000 feet

difference in altitude between places on the 16-mile system, of which 8½ miles have already been built. Less than 50 per cent. of the line has a gradient of 0 to 3 per cent., while 21 per cent. has 5–7 per cent. grade, 3 per cent. has 7–9 per cent., and 2 per cent. has over 11 per cent. grade. Curves of 66 feet radius coincide with 8 per cent. grades. In many parts the roads are only 18 feet wide. Except 440 yards, which is paved, the system is laid in macadam on meter gauge with 4½ in., 60 lb. girder rails, laid on 6 feet iron sleepers, weighing 46 lb. each. The total weight of permanent way is 170 lb. per yard in macadam, and 200 lbs. per yard in paved roadway. On the 11·3 per cent. grade, wooden boards 4·4×4·8 in. are placed alongside and outside the rails for the safety brake. The rails are bonded with 8 mm. copper wire, keyed and soldered to the rails. The power station is central, and contains three sets of Crossley gas engines connected through Raffard friction couplings to Thury dynamos. Each set has two twin 75 H.P. gas motors, with 8 feet fly-wheels weighing 6½ tons each. The gas generating plant, by Fichet and Heurtey, of Paris, is a modified form of Dowson plant, in three sets corresponding to the three gas engines. The system employed admits of the use of poor and small-sized St. Etienne coal (1/5 in. to 4/5 in.) costing less than 28s. per ton delivered, in conjunction with Belgian anthracite of the same size. The cost of fuel works out at 0·5d. per car mile, corresponding to 1·3 lb. coal per H.P. hour. A Pollak battery of 700 ampere hour capacity works in parallel with the dynamos and the line. The rolling stock comprises 21 four-wheeled motor cars, carrying 14 passengers inside and 9 on each platform, and fitted with two 20-H.P. Thury motors with single-reduction pinion gearing 1:9. The motors always run in parallel, the regulating resistances being on the car roof: this gives smooth and instantaneous starting. On all down grades the motors are run as generators on the resistances. On the 11·3% grade there is a stopping-place requiring a starting current of 120 amperes at 500 volts at the generating station. A special safety brake is used consisting of two toothed steel blocks, which can be forced down on to the planks outside the rails with a force of one ton per block. This is effective for instantaneous danger-stops. Heating is effected by radiators of 2·5 kw. Current is taken from the trolley wire by a slide shoe with renewable contact of alloy. The cars average 50 miles per car per day, and receipts vary from £12 to £60 per day. The number of passengers carried is 50 per head of population per annum. Tables of staff, cost of construction, working expenses, and other interesting data are given. The costs of the power station and plant, comprising three 150 H.P. sets, and a storage battery equal to a further unit, work out as follows :—

For gas plant and gas motors, £13 per H.P.; for dynamos and accessories, £8·9 per H.P.; for accumulators, including a reserve battery, £17·2 per H.P.; for land, works, and buildings,

£15·8 per H.P. It is contemplated to eventually use the present station as a reserve, working the whole system from water-power at St. Maurice on the Rhone, where 9,000 to 14,000 H.P. are available. The transmission over the 40 miles to Lausanne is to be direct current at 22,500 volts in two cables of 150 sq. mm. section; 7 per cent. loss in transmission is estimated. The author notes that there is a continuous current transmission at 14,400 volts at Chaux de Fonds (Jura). E. H. C.-H.

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928. *Electric Traction at Washington.* (Elect. World, 32. pp. 707–715, 1898.)—An account is given of the construction of the conduit, and of the equipment of the new power station at Washington. The alterations necessary in the existing cable conduit are described. The power house contains eight boilers, each of 350 nominal H.P., which supply five 800 H.P. Allis-Corliss tandem-compound engines. The exhaust of each engine first passes through a Hartford feed water heater, and then to its own jet condenser. There is a very complete plant for the handling of coal and ashes. The switchboard is of standard General Electric construction. It includes throw-over switches so that the polarity of any section may be reversed; if earths occur on different sections they may by this means be all placed on the same side of the system, and a short circuit from this cause avoided. A single starting-rheostat is made to serve for any of the boosters by specially designed switches. There is a protective device for the booster generators, which acts in the event of the circuit breaker of the motor opening. A water rheostat is also included for the purpose of burning out earths. W. R. C.

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929. *Accumulator Sub-stations for Electric Tramways.* (Elect. World, 33. pp. 75–76, 1899.)—To cope with the rapid increase in the load on the generating plant of the Metropolitan Street Railway Company, New York, U.S.A., two storage battery sub-stations have been installed, each consisting of two batteries in parallel, and capable of giving 8,000 amperes for one hour. A booster is used to assist in charging and discharging the battery, but during a large part of the day the battery "floats" on the line; the number of cells in series is not varied at any time. The battery is to be kept on the mains in emergencies, whatever happens. The booster is provided with differential excitation by means of series and separate exciting coils, the latter being connected with two resistances joined across the mains in such a way that the exciting current can be varied in strength and in direction by turning a switch, without ever opening the circuit. The ordinary load of each sub-station is about 800 kilowatts.

A. H. A.

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930. *Mixed System at Hanover.* (Street Rly. Rev. 8. pp. 801–802, 1898.)—This article is an abstract from a paper read by T. Krüger at the Geneva meeting of the Permanent International Tramway Union. Information is first given as to the treatment of the cells. The batteries weigh from 4,400 to 5,500 lb., and comprise 202 cells with a capacity of 25 ampere hours at a discharge rate of 25 amperes. After running 5,000 to 7,500 miles the batteries are cleaned; when this is again necessary, new plates are fitted. Negative plates are repasted, the grid lasting through six "repastings," or 150,000 miles. The cost of repasting is 76 marks (£3 16s.) per car. New positives cost 707 marks (£35 7s.) per car. The cost of maintenance and renewals from August 1, 1896, to August 1, 1898, amounted to 0·405d. per car mile. In order to obtain a long life of battery it should be chosen so that not more than one-half the capacity will be required. The average life of batteries in 37 cars was 23,417 miles; that of the positives in seven cars was 24,528 miles; and that of the negatives in two cars was 23,321 miles. Inspection and cleaning are essential. The power apparently costs ¼d. per car mile when the batteries are in use, and ⅙d. per car mile when not in use, in excess of that which would be required with a simple trolley. W. R. C.

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931. *Liverpool Electric Tramways.* (Railway World, 7. pp. 372–376, 1898.)—Large new double-bogie centre-vestibule cars are now in use. They carry forty passengers, and cost less than the ordinary motor and trial car, which do not together hold as many. They are fitted with Standard air brake equipment, the compressor being geared to the axle and automatically put into action only when the air-pressure falls. A constant pressure of 3½ atmospheres is maintained in the reservoir. The brake cylinder acts directly through a push-rod on to the equalising lever, through which the hand-brakes also operate. The connection, however, is not rigid, so that when the hand-brake is used the power mechanism remains at rest. On emergency the 13-ton cars at full speed can be stopped within their own length. (See also 1899, Abstract No. 517.)
E. H. C.-H.

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932. *Electric Traction at Lyons.* (Electrician, 16. pp. 331–338, 1898.)—The whole of the above traction circuit has been divided into five independent sections, and each connected to a feeder in such a manner that if an accident occurred to one of these sections, the remainder of the circuit would not be affected. A portion of the circuit is worked on the overhead trolley system, and the remainder by means of the central underground conduit system. The "go" and "return" cables to the motors are insu-

lated from the rails and consequently from earth, and current is supplied to them by two feeders entirely insulated and completely insulated from the other feeders of the circuit. A map shows the disposition of the feeders, a special feeder being provided for the underground portion of the line.

The feeders consist of rubber-covered cable, protected by two iron armourings.

The positive feeders were calculated according to Kelvin's formula for maximum economy. This could not be applied to the negative feeders owing to the necessity of making the point of contact of these to the rails, equipotential. In order to control this drop, and regulate it from the station by means of auxiliary resistances, the ends of these cables were connected by means of pilot wires to special instruments, allowing the difference of potential between the ends of each of the feeders to be measured. The power house is one of the most important which have been built in France. The switchboard is provided with a water resist ance which answers several purposes. It can be connected to one of the feeders, and thus reduce the pressure.

In this manner one can prevent too great a leakage of current in the event of the culvert becoming flooded. In the case of a short circuit on a feeder the resistance becomes of use in reducing the pressure to allow just enough current to pass to burn out the fault. This resistance is also used for sending a current through the rail bonds between the ends of two feeders for the purpose of testing the resistance of the bonds. L. J. S.

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933. *Jungfrau Electric Railway.* **C. King.** (Railway World, 7. pp. 358–362 and 397–400, 1898.)—The Jungfrau Electric Railway has already been referred to in Science Abstracts, No. 91 (1898). The present paper contains a description of the rack rail designed by M. Strub; the designer's aim being to produce a rack which should be easy to make, cheap in maintenance, and, above all, should as far as absolutely possible provide against all contingencies. The most serious and difficult point to be met is the possibility of the pinions mounting the rack. The rack consists of a single rolled rail 170 mm. height, with a high head, in which the gearing teeth are formed. The bottom of the tooth space is inclined from the centre line, so that any ice formed on the rack may be forced out by the pinion. The lower part of the head is tapered downwards, and is utilised for safety grips, which come into action if there should be any tendency for the pinion to mount the rack. The grips can also be operated by hand, so that they may form a very powerful and absolutely safe emergency brake. The rack weighs 34 kgms. per metre. It has a tensile strength of 29 tons per sq. in. and an elongation of 20 per cent. A description of the tunnelling operations now being carried on is given, and also a short description of the power plant. A. S.

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934. *Experimental Electric Railway Line.* (Zeitschr. Elektrotechn. Wien, 16. pp. 589–591 and 605–608, 1898.)—The article contains an illustrated description of the arrangements about to be adopted by the Prussian Government in connection with electric traction experiments on a section of the Wannseebahn suburban railway in Berlin. A. H.

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935. *Electric Traction for Metropolitan Railways.* **P. Dawson.** (Soc. Arts. Journ. 47. pp. 399–407, 1899.) — Steam locomotives are unsatisfactory where stops are frequent; they cannot speed up rapidly, chiefly because the torque on the driving axles constantly varies with the reciprocation of the pistons; their fuel consumption is practically the same whether standing still or exerting full power. Electric energy may be transmitted to motors on the cars, through conductors laid along the track, by direct current, with or without accumulator substations and negative boosters to reduce the drop, or by polyphase currents, or by a combination of both. The three-wire system, using the rail as the neutral wire, has been tried and found wanting. Parshall supports the contention that for any power station of more than 4,000 kw. capacity, *i.e.*, for all suburban and metropolitan lines, the polyphase system is commercially the only admissible one. The chief aim is a high average speed, with a low maximum. The time between reaching maximum speed and applying brakes should be at least 4 to 6 times that required for stopping the train, so as to allow for errors of judgment. By suitable arrangement of gradients at stations, 40 to 50 per cent. of the total power required by a train may be saved. Potter's tests showed that during acceleration the average current required was 32 amps. per ton weight of train. On the Metropolitan Elevated, Chicago, a 4-car train with an average speed (exclusive of stops) of 12·2 miles per hr. required ·042 unit delivered at switchboard per ton-mile: at 14 m.p.hr. this figure rises above ·050. A table is given showing the changes in power consumption over a given distance (2,000 ft.) in a given time (75 secs.) when the times of application of power and brakes are varied. With power applied for 7·5 secs., the maximum speed was 25·75 m.p.hr., brakes were on for 10 secs. and the consumption was ·035 unit per ton. Respectively corresponding figures were 53·0 secs., 36·5 m.p.hr., 22 secs., and ·084 unit per ton. From actual results on the Chicago Elevated and the Metropolitan (London), 25 miles per hr. is attained in 10 secs. with electric traction, and in 33 secs. with steam locomotives. The consumption of coal on English main lines is 3 to 4 lb. per I.H.P., which is electrically equivalent to 13 lb. of coal per B.T.U., whereas a unit can actually be delivered at switchboard for a trifle over 3 lb. of coal. The three types of elevated railway equipment are (1) the steam locomotive, using 10 to 15 per cent. of train weight for

traction; (2) the electric locomotive, using 30 to 35 per cent.; and (3) the Sprague multiple-unit system, using anything up to 60 per cent. of the train weight. With the last system on the S. Side Elevated in Chicago, the transportation expenses for July, August, and September, 1898, were 1·9 cents per car mile, whereas for the same months in the previous year with steam locomotives they were 2·8 cents per car mile.

A few details are given of the two large power stations now being equipped for the Metropolitan and Third Avenue lines in New York. The former will contain 11 direct-coupled 3,500 kw. sets with Allis vertical engines, giving 6,600 volts at a frequency of 25 and a speed of 75 r.p.m. The fly-wheel rims will weigh 100 tons. Sub-stations will reduce the pressure to 350 volts, which will then pass through rotary converters to the line at 500 volts. As regards long-distance transmission, 4,000 H.P. is now regularly transmitted 85 miles to Sacramento, California, at 30,000 volts; 1,000 H.P. at Telluride, Utah, are sent 55 miles at 40,000 volts.

Discussion (pp. 408–412, 1899). **C. Carus-Wilson.** For the class of service dealt with in the paper, the efficiency curves of motors are of little importance, as the value of the efficiency at a certain speed does not go for much. The value of gradients at stations could be shown to be greatest when they act during the first few seconds, but this is practically impossible, and hence too much advantage should not be claimed for them. **L. Gaster** said trains had been working for some time in Switzerland with three-phase motors. **E. K. Scott** confirmed this, and believed three-phase motors would accelerate as quickly as continuous current. **J. Swinburne** remarked that a drawback to a polyphase motor was that it required three contacts instead of two, but he could not see why it should not give sufficient starting torque. To get large torque with direct current, the armature current and the field excitation are increased. This can equally well be done in a polyphase motor where, whatever the nomenclature, the two elements exist. One element is connected to the line and gets alternating currents, and the field or the induction can be increased by reducing the number of turns. The other element has an induced current in it which depends solely on the resistance in circuit to start with. With regard to steam locomotives, the acceleration difficulty is that one cannot do more than fill the cylinder with steam, and if the cylinder is large the expansion is too much when running rapidly. **W. M. Mordey** remarked that with direct currents, the small E.M.F. and large current required for starting are obtained by waste in resistances. With alternating currents a back E.M.F. can be inserted, which is not wasteful. E. H. C.-H.

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936. *Three-Phase Currents for Traction.* **E. K. Scott.** (Instit. Elect. Engin. Journ. 28. pp. 108–119, 1899.)—The

Zermatt-Gornergrat Railway was the first to be equipped with three-phase plant. It is 5½ miles long and works with a rack, the heaviest gradient being 20 per cent. There are two double trolleys of "lyre" pattern (two per phase), each being insulated in the middle, so as to take current from the two wires. The complete train, weighing about 28 tons, runs at 4¼ m.p.hr., the total tractive effort being 6 tons. Each locomotive carries two 90 H.P. motors of the asynchronous three-phase induction type, with wound rotor and contact rings, permitting the introduction of ordinary low-voltage resistances for speed regulation. They start under full load with not more than the current required at normal speed, run at 800 revs. per min. with 40 periods per sec., weigh 2½ tons each, and actuate the rack wheel through double reduction, 12 to 1, gearing. In descending, when the motors reach speed of synchronism they act as generators, and cannot exceed that speed. If one wire be interrupted, the motors act as single-phase machines of reduced power. Current is generated at 5,400 volts and transformed down to 540 volts at three sub-stations by two groups of three 30 kw. single-phase transformers at each station. An important point in three-phase traction is that with the controller at the full speed notch the speed is, within limits, independent of load and gradient. The system has a large field on lines running long distances between stops. Appendices give short descriptions of the Lugano, Jungfrau, Evian-les-Bains, Engelberg, and Thun multiphase lines. E. H. C.-H.

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937. *Electric Traction.* **H. F. Parshall.** (Elect. Engin. 23. pp. 114–116, 1899. Paper read before the Northern Society of Electrical Engineers.)—Lighting plant usually works at full load only a few hours per day, whereas traction plant has many hours of it, justifying greater capital expenditure in coal-handling machinery, steam piping, mains, &c. A heavy fly-wheel is the most economical method of getting the maximum effort from the steam engine for taking overloads. Good governing costs no more and certainly does no harm. In large units the mechanical and electrical requirements as to speed generally coincide. The distance at which continuous currents become more efficient than multiphase currents varies with the ratio of the average to the maximum temporary load. Rotary converters at constant speed give constant volts regardless of load, and can therefore satisfactorily supply both traction and lighting installations. Where there are rotary converters feeding into a network at constant voltage care must be taken to select engines with constant angular velocity and mains with small drop, equal in each phase. The greatest difficulty in large multiphase stations is the switching apparatus, particularly the circuit breakers. The limit for a 500-volt continuous current station is reached at 5,000 kw. output. Beyond this, multiphase transmission with rotary transformers and continuous current distribution becomes necessary.

E. H. C.-H.

938. *Power Distribution for Electric Traction.* **E. Wilson.** (Engineer, 87. pp. 51–52, 1899.)—In this paper the author compares the systems in use, and discusses the subject in general terms. Alternate-current and direct-current generators, overhead and underground conductors, two- and three-wire systems for traction, high tension transmission, and storage cells are discussed in turn. A. S.

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939. *Successful Running of Suburban Railways.* (Street Rly. Journ. 14. pp. 755–763, 1898.)—This article deals with the influence of competing tramways upon the successful financial running of suburban railways which only stop at fixed stations. The New York and Brooklyn railroads have lost heavily during the last two or three years owing to the competition of fast trolley street cars. The only way to counteract this competition is to adopt high acceleration on the railroads. The accelerations are compared of the steam locomotive, of the electric locomotive, and of the "multiple unit" (Sprague) system. Speed curves are given of each of these. Tables are also given of acceleration and braking data of several railways, due to W. B. Potter. Maintenance and general expenses are discussed. In 1897 the operating expenses of the Manhattan Company, working with steam, were 12·3 cents per mile (43,181,582 car miles). If the same service had been run electrically, it is estimated that the expenses would have been 10·9 cents, and if 50,000,000 car miles had been run with increased acceleration the expenses would have been 9·55 cents. A higher dividend would have been earned even if the electrical equipment had cost $10,000,000. W. R. C.

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940. *Mechanical Traction.* **E. A. Ziffer.** (Street Rly. Journ. 14. pp. 710–713, 1898.)—Steam motors have been much improved, but the location of the boiler next to the passengers is objectionable. Of stored steam motors, the Dodge promises success. Compressed air systems have made little progress in Europe, but are to be tried on a large scale in America. Gas locomotives are an advance on gas motor-cars, but the smell still penetrates. Gasolene motors are not so good as benzene motors, which are being tried on the Wurtemburg State Railways. Traction by accumulators and by surface-contacts is still experimental. The third-rail system is the cheapest to install of any, and gives good results on private roads. E. H. C.-H.

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941. *Electrolysis in Ground Returns.* **A. B. Herrick.** (Street Rly. Journ. 14. pp. 775–779, 1898.)—When current leaves a metallic surface buried in the earth, it does not carry

with it the decomposed metals and deposit them on the kathode as in a plating bath. Instead of this, they lie adjacent to the surface acted upon, usually in the form of oxides, which increase the resistance of the leakage path. Water accumulates at the negative plate and is repelled from the positive: this action increases with the current density. The voltage at which electrolysis begins varies from 1·5 for pure water to 0·37 for a 10 per cent. sodium chloride solution. When a station is shut down there is often 0·5 volt due to the battery action of the buried iron. Practical methods are given for measuring current in a water-pipe, between the soil and the pipes, &c. E. H. C.-H.

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942. *Thompson-Walker Surface Contact System.* **M. Walker.** (Instit. Elect. Engin. Journ. 28. pp. 239–272, 1899.)—A surface contact system cannot be satisfactory unless (1) the contacts in the roadway do not form obstructions to traffic, (2) the method of picking up current from studs by means of a skate is feasible under practical working conditions, and unless (3) the studs can be made perfectly safe. Hollows $\frac{3}{4}$ in. deep are common in roads; the studs in Thompson's system are only $\frac{3}{4}$ in. above the road surface. A stud is easier to insulate or renew than a rail. The skate is made of U-steel girder $4\frac{1}{8}'' \times 2\frac{1}{2}'' \times 18$ feet long, bent up at the ends and so carried on springs as to allow a tilting of the ends. The switches take $\frac{1}{10}$ second to close, and studs can therefore be $14\frac{1}{2}$ feet apart for an 18-feet skate. Tests show that the average leakage in wet weather will be $\frac{1}{2}$ ampere per car, rising to 5 amperes in a bad road. The switch is based on the principle that a magnet cannot attract air. The iron plunger, which works the actual contact-yoke with a hammer blow, is magnetised by a solenoid, but will only rise when the skate comes over it. The plunger is a loose fit in a cylinder and cannot stick. If the yoke did stick up the plunger is arranged to make an earth and blow the fuse. The studs are faced with hard phosphor-bronze, and form the lids of the switch boxes. Any one can be removed, with its attached switch, in two minutes. A 500-volt accumulator battery is carried for making the first stud alive. (See also Abstract No. 217, 1899).
E. H. C.-H.

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943. *Stendebach and Linker's Combined Conduit and Surface-Contact System.* (Elect. Rev. 44. pp. 151–154, 1899.)—The conduit admits a merely mechanical plough on the car, which works a rack in the adjacent switch-box, thereby rotating an insulated disc carrying contact pieces, which connect the feeder to the stud in the road above. E. H. C.-H.

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944. *Conduit Construction in New York.* (Street Rly. Journ. 14. pp. 791–794, 1898.)—The Third Avenue Railroad Co. is about to change over its 60 miles of line from horse and cable to conduit. The new 107-lb. girder rails in 60 feet lengths will be carried on wooden stringers $5\frac{1}{2}$ in. wide $\times$ 6 in. high, laid in 30 feet lengths: this will give an easy riding track. The third rail, of 21-lb. T-steel, and its insulators are similar to those used by the Metropolitan Street Railway Company. In parts, the old cable conduit will be adapted; the rails will be carried from the yokes on spring liners. Thirty-two feet convertible cars will be used with "G.E. 52" motors and Brill "27 G" bogie trucks: total weight of car, 36,000 lb. Provision is made for attaching a special trolley pole for manipulation in the car-sheds.

E. H. C.-H.

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945. *Thomson's System of Electric Train Control.* (Elect. Engin. N.Y. 27. pp. 95–96, 1899.)—To have each car of a train independent is conducive to economy. E. Thomson provides a master-controller in positive synchronous relation with the individual motor controllers. A diagram of connections is given.

E. H. C.-H.

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946. *Track Construction.* **D. F. Carver.** (Elect. Rev. N.Y. 33. p. 187, 1898.)—Good foundation is essential for good construction. If not naturally good, broken stone or gravel will make it so. Ties should be of best yellow pine, sawed four sides, and having a bearing of $4\frac{1}{2}$ square feet per tie; 24 ties per 60 feet rail is found best. Ties under joints should be tamped throughout their length; others at their ends. It is now common to bevel rails on the tread to give the wheels a bearing over the whole width. The lightest section of 9-in. rail is more than amply strong, hence it is found desirable to roll the web down to thinnest possible and accept the loss (about 0·25 per cent. of rails laid) due to rails splitting along the web owing to unequal tension. A satisfactory solution of the rail-joint problem is fast being found in either welded or mechanical joints. The latter makes use of the base of the bearing surface under the head and of the surfaces of the rail. With girder rail in block-paved streets, a rail filler must be used; burnt brick crumbles under heavy traffic, and has been replaced by hemlock planks, which give the best results on the investment. The author has found that the interest on concrete between ties to prevent pavement from sinking is often in excess of the maintenance charges which it is intended to prevent.

E. H. C.-H.

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947. *Applications of Accumulators.* **J. Appleton.** (Elect. Engin. N.Y. 27. pp. 150–151, 170–172, and 201–202, 1899. Paper read before the New York Electrical Society.)—After referring to the present position of accumulators from the commercial point of view, the author discusses their advantages and their application on a large scale. The Chicago Edison Company has installed with good results a battery capable of discharging at the rate of 11,000 amperes for $1\frac{1}{2}$ hours. As to whether batteries should be used at the main power house or at sub-stations depends upon the conditions of each particular case. Where power is charged for at so much per H.P. per annum, the power being available twenty-four hours per day, it is worth a customer's while to put in a battery, and to rent a smaller H.P. In connection with traction systems, a battery may be installed at the power house, or at the end of a long feeder. The Buffalo Street Railway Company has erected a battery at the power house which is charged by power from Niagara, and enables the Company to shut down for twelve hours a day. The power rented from Niagara is also much less than was the case before the battery was in use. As an instance of the use of batteries at the end of feeders, the system of the South Side Elevated Company of Chicago may be mentioned. Other installations are also described.

W. R. C.

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948. *Central Station Design.* **B. J. Arnold.** (Elect. World 33. pp. 172–174, 1899. Paper read before the North-western Electrical Association).—The author refers to the present trend of engineering practice, first as to boilers, engines, generators, economisers, mechanical draught, condenser plant, motor-driven auxiliaries, multi-circuit dynamos, &c., and then to the central station as a whole. W. R. C.

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949. *Charging for Electrical Energy.* **G. Pellissier.** (Soc. Int. Elect. Bull. 15. pp. 395–415, 1898.)—The author describes and discusses in detail the various systems of charging in use, and concludes that the Wright system most nearly approaches the ideal indicated by theory. In his opinion it would be better to double the fixed price, and to make the reduced price applicable after the first half-hour of use, instead of the first hour as at present, in order to place the whole of the consumers on the same basis. A. H. A.

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950. *Charging for Electrical Energy.* **W. Arnot.** (Elect. Engin. 22. pp. 716–719, 1898.)—In this paper, read before the Institution of Engineers and Shipbuilders in Scotland, the author discusses electricity meters and methods of charging for electrical energy. By quotations from provisional orders it is shown that

all meters should be examined and certified by inspectors appointed by the Board of Trade. Load curves are given for Edinburgh and Glasgow, and the working costs compared in detail. The Wright system of demand indicators is explained, and compared with other systems, and the question of charging for motive power is briefly dealt with. A. H. A.

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951. *The Photometry of the Enclosed Alternating Arc.* **C. P. Mathews, W. H. Thompson,** and **J. E. Hilbish.** (Amer. Instit. Elect. Engin. 15. pp. 599–617, 1898.)—Photometric measurements with enclosed arcs are less subject to colour difficulties than open arcs, since the enclosing opalescent globe absorbs rays of short wave-length in greatest proportion and brings the colour of the arc nearer that of the standard. An obstacle to careful measurement is the variation of the intensity of alternating arcs due to the wandering condition of the arc. To enable instantaneous photometric readings to be taken use is made of a device due to Matthews, by which settings can be recorded and read after a series of observations have been taken. (See 1899, Abstract No. 542.)

The standard source is a glow lamp, being referred after each test to the Hefner lamp.

The following is a summary of the results of the test of one lamp :—

Volts	103·2
Amperes	5·84
Apparent watts	602·0
True watts	407·0
Watts in mechanism	80·0
Power factor	0·67
Maximum intensity	203·0
Direction of maximum intensity below	50°
Ditto above	30°
Mean hemispherical intensity—	
Upper hemisphere	91·8
Lower hemisphere	129·1
Mean spherical intensity	110·5
Watts per mean spherical, Hefner unit	3·68
Watts in arc per mean „	2·96
Watts in arc	327·0
Character of globes	opalescent inner.
Carbons	½-inch "Electra."

The power factor is due to the inductance in the mechanism.

This is compared with a direct-current enclosed arc, and the authors infer that as regards efficiency, or watts per Hefner unit, the direct-current arc is superior to the alternating-current one.

W. G. R.

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952. *Arc Light Formulæ.* **W. Harkness.** (Amer. Assoc. Proc. 47. pp. 140–142, 1898.)—The variable elements in an arc lamp are: 1st, the energy resulting from the drop of potential between the carbons; 2nd, the diameter of the carbons; 3rd, the length of the arc; and, 4th, the quality of the carbons.

If M is the maximum intensity of the light emitted when the power consumed is W watts, and the diameter of the carbon is d millimetres, then, according to Max Schreihage,

$$M = \frac{n\, W^{\frac{3}{2}}}{d}$$

where n is a constant determined by experiment.

The author gives an empirical formula deduced from tests on thirteen arc lamps at the Paris Exhibition of 1881, in the form—

$$M = 0{\cdot}0575\ (1 \pm 0{\cdot}068)\ \frac{W^{1{\cdot}6}}{d}\ \text{carcels},$$

and another from tests on twenty-five lamps at the Antwerp Exhibition of 1885, in the form

$$M = 0{\cdot}0759\ (1 \pm 0{\cdot}0208)\ \frac{W^{1{\cdot}6}}{d}\ \text{carcels}.$$

Other tests by L. B. Marks in 1890, on seven lamps, give

$$M = 0{\cdot}0802\ (1 \pm 0{\cdot}0888)\ \frac{W^{1{\cdot}6}}{d}\ \text{carcels}.$$

The diameter of the carbons is given by

$$d = m\ \sqrt[3]{W}$$

where—

$$d = 1{\cdot}52 \pm 0{\cdot}16.$$

Also if H is the horizontal intensity and S the mean spherical intensity, the formula

$$S = \tfrac{1}{2}\, H + \tfrac{1}{4}\, M$$

is deduced empirically, and putting

$$\frac{M}{H} = n$$

tests on fifty-six lamps give

$$n = \frac{M}{H} = 2{\cdot}416$$

W. G. R.

953. *Most Economical Life of Incandescent Lamps.* **B. L. Montel.** (Zeitschr. Elektrotechn. Wien, 16. pp. 594–596, 1898.)—The author explains a graphical method of determining the number of hours during which an incandescent lamp should be kept in circuit in order to comply with the condition of lowest cost per candle-hour. A. H.

954. *Bergmann Arc Lamp.* **P. Letheule.** (Électricien, 16. p. 400, 1898.)—In this lamp the only regulating mechanism consists of a series solenoid and an iron core. The core forms the carbon-holder and is made heavy so that the weight of the carbon is negligible relatively thereto. The solenoid has its interior made so as to fit close to the core in the middle of its length but tapers away towards its ends, so as to render the magnetic attraction uniform throughout the travel of the core. The upper end of the solenoid is closed, so as to form an air dash-pot for the core. The current passes to the upper carbon through the core and the metal tube on which the solenoid is wound. C. K. F.

955. *Sonia Enclosed Arc Lamp.* (Elektrotechn. Ztschr. 19. p. 660, 1898; also Écl. Électr. 17. pp. 488–490, 1898).—This is a ring-clutch lamp, in which there are various improvements in details. Drawings are given in the original paper. C. K. F.

956. *Arc Lamps.* **R. A. Ross.** (Canad. Elect. News, 8. pp. 222–223, 1898.)—In this article the author deals with the comparative advantages of the various systems of arc lighting, and gives the following table (in which "Outside" indicates outdoor lighting, and "Inside" indicates the lighting of interiors):—

LIGHT-GIVING EFFICIENCIES OF DIFFERENT ARC LIGHT SYSTEMS.

	Amperes	Volts in		Watts in		Candle Power.		Watts per C.P.		C.P. per H.P.	
		Arc.	Line.	Arc.	Line.	Outside.	Inside.	Outside.	Inside.	Outside.	Inside.
DIRECT CURRENT.											
Series Open	10	45	50	450	500	650	450	0·7	1·0	750	520
Series Enclosed	6·5	70	75	450	500	375	450	1·2	1·0	440	520
Constant Potential Open	10	45	55	450	550	650	450	0·7	1·0	750	520
Constant Potential Enclosed	5·6	80	104	450	580	375	450	1·2	1·0	440	520
ALTERNATING CURRENT.											
Series Open	15	30	33	450	500	375	300	1·2	1·5	470	370
Series Enclosed	6·5	70	75	450	500	225	300	2·0	1·5	285	370
Constant Potential Open	15	30	33	450	500	375	300	1·2	1·5	470	370
Constant Potential Enclosed	6·5	70	75	450	500	225	300	2·0	1·5	285	370

C. K. F.

957. *Submarine Arc Lamp.* (Elect. Rev. N.Y. 33. pp. 241–242, 1898.)—This article is accompanied by two photographs of an arc lamp designed by Messrs. F. G. Hall, jun., and I. E. Burdick, for use in diving and wrecking operations. The description is somewhat meagre from a technical point of view.
C. K. F.

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958. *Arc Lamps.* **G. Richard.** (Écl. Électr. 17. pp. 148–154, 1898; and 18. pp. 174–182, 1899.)—An illustrated description of a number of arc lamps. EDITOR.

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959. *Nernst Electric Lamp.* **J. Swinburne.** (Soc. Arts Journ. 47. pp. 253–260, 1899.)—The light is obtained by rendering incandescent by means of an electric current highly refractory oxides worked up into little white rods. Each rod is mounted on two platinum wires by means of a paste made of refractory oxides. Such rods are, when cold, good insulators, but become conductors when heated. Since the rods fall in resistance as the temperature increases, an increase of current produces a decrease of resistance. This tends to give instability in running in parallel on supply circuits. This instability is corrected by a series resistance made up of fine wire and amounting to 10 or 12 per cent. of the whole resistance of the lamp. The consumption, including resistance, is 1·5 watts per candle for large lamps, and 1·6 for small lights. The lamp will not light up of itself, since the rod is an insulator when cold, but may be started by warming with a match or spirit lamp. The small lamps and the lamps of medium size are in practice started by a heating resistance. This is arranged close to the rod and in shunt to it. As soon as the rod is hot enough to conduct, its current works a tiny cut-out in the resistance circuit. In large lamps the heating system is a little more elaborate, as the resistance arrangement is arranged as a sort of hood which covers the rod. As soon as the rod conducts, not only is the resistance circuit broken, but the electromagnet lifts the little hood clear off the rod. In all these forms the rod and its mounting are replaceable without interfering with the rest of the lamp. The Nernst lamp is cheaper as to maintenance than either glow lamps or arc lamps, and cheaper than the latter in first cost. W. G. R.

TELEGRAPHY AND TELEPHONY.

960. *Space Telegraphy and Syntony.* **O. Lodge.** (Instit. Elect. Engin. Journ. 27. pp. 799–852, 1898.)—The author points out that slow magnetic pulsations being unaccompanied by an alternating electrostatic field do not emit energy, and do not therefore require a detector of radiant energy, a coherer; but the changes of magnetic conditions over a large area may be integrated by a telephone and circuit. The distance between two signalling coils is proportional to the two-thirds power of the diameter of the coils. Hence, coils of twice the circumference will signal to more than twice the distance with a given primary current. An emitting and receiving circuit each contains a condenser in series, and are tuned to respond to each other. The condenser is kept small by using frequencies of 384 per sec. The author proves that a simple induction method unaided by syntony is extravagant either in copper or power. With syntony, high frequency is an advantage, and the impedance is simply the resistance. An expression for the induced current in each case is given. The relative effects of conduction and induction at Lavernock are discussed. The self-induction capacity and frequency in several experiments (signalling up to 2 miles) are discussed, as also are the conditions and theory of tuning, the calculation of the best size and shape of coil for violent resonance and for maximum magnetic moment. A tuning-fork telephone receiver adapted to reproduce a special note, and a suspended coil receiver for working a transmitter to magnify sounds are described. Repeated magnification, a combined tuning-fork magnifying system, and a call are explained. M. O'G.

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961. *Space Telegraphy (Inductive).* **S. Evershed.** (Instit. Elect. Engin. Journ. 27. pp. 852–869, 1898.)—The author gives fundamental formulæ for the induction in secondary coil when telegraphing by horizontal rectangular coils. To get the greatest mechanical energy in the secondary the impressed E.M.F. must be in step with the current and the condition for maximum activity of a motor must be fulfilled, viz., the back E.M.F. must equal half the impressed E.M.F. The readable current in a Gower-Bell receiver was found by measurement to have a maximum (crest of wave) value of $2{\cdot}9 \times 10^{-6}$ amperes. The most audible frequency is 400, but the author anticipates that at this speed absorption by the earth will rapidly damp out the waves.

An ingenious relay receiver is described. It consists of a rectangle of wire having one end free to vibrate in a permanent magnet field. A current of the proper frequency will swing the rectangle into contact either with a stop or another similar rectangle vibrating. The amplitude is proportional to the impressed E.M.F. When E.M.F. and current are in the

same phase, the power available in the secondary working a telephone at 400 $\frown\!\!\smile$ is 600 times greater than that available in the rectangle relay at 16 $\frown\!\!\smile$. M. O'G.

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962 *Magnetic Space Telegraphy.* **W. H. Preece.** (Instit. Elect. Engin. Journ. 27. pp. 869–967, 1898.)—In 1886 the author found that on earthing the ends of two (horizontal) speaking coils 4·5 miles apart, the results were the same whether the earth or metallic returns were used. Heaviside communicated between the earth's surface and a colliery 350 feet deep, but 400 feet of water was found to obstruct telephonic signals. The empirical formula

$$x = 1{\cdot}9016\sqrt{\frac{C_1 l}{r_2}}$$

determines the distance x which should separate wires of length l, C, being the primary current and r_2 the resistance of the secondary. This established the fact that it was advisable to use copper conductors of the largest gauge that could be obtained.

An attempt to communicate from England to Ireland on the circuits from Carlisle to Haverfordwest, and from Belfast to Wexford, was spoiled by overpowering sounds of uncertain origin.

An appendix is added, explaining diagramatically the effects of adjacent rectangular coils. M. O'G.

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963. *Wireless Telegraphy and Electromagnetic Waves.* **Della Riccia.** (Bull. Ass. Ing. El. Liège, 9. pp. 161–230, 1898.)—This is a continuation of the author's former paper (see 1898, Abstract No. 1420), in which Marconi's experiments and results are described. J. L. H.

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964. *Wireless Telegraphy.* **A. Turpain.** (Comptes Rendus, 127. pp. 1208–1210, 1898.)—This paper considers the simultaneous transmission of signals along one wire to different stations by using Herzian waves of different wave-lengths and having resonators at the different stations, each one tuned to receive only the waves of one wave-length.

The principle of interference is used to stop or start the transmission of waves of any particular wave-length along the wire from the particular resonator at the transmitting station. The two wires from the terminals of the resonator are joined together and then to the line wire; but between the resonator and the line wire a side branch, equal in length to one-half the wave-length, is inserted in one of the terminal wires. According as this branch is short-circuited or not, the resonator at the far station receives

the signals or is silent. (This may be *vice versâ*, depending on the system of resonators.)

An experimental installation with a line 170 m. long, having three stations on it, was erected, and by the aid of five resonators simultaneous and independent communication was obtained between every two stations. J. B. H.

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965. *Wireless Telegraphy.* **A. Broca.** (Revue Scientif. 11. pp. 193–199, 1899.)—The author deduces from Poynting's conclusions that the heating of a conductor conveying a current is due to electrical energy coming to that conductor across its surface. Maxwell and Hertz showed that electrical waves move at the same speed along wires as across the air. Marconi's vertical wire when connected to Righi's spark knobs is compared to a pendulum of slow period whose point of support is a rapidly vibrating tuning-fork. The entire system will have a slight motion determined by the pendulum, but nearly all the energy will be absorbed in vibrating the bob. These vibrations propagate themselves along the wire. The flux of energy will also be along the wire, and when this flux arrives at the end of the wire its direction is determined in a plane at right angles to the wire, because the electrical force is normal to the surface at the end. The result is a plane wave corresponding to polarised light.

The history of coherers is summarised, and it is pointed out that when the metal powders are immersed in copal varnish there are given out minute globules of gas, which render the coherer insensitive, but which are reabsorbed as time goes on. Marconi's method is then described. M. O'G.

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966. *Pacific Cable.* **C. Bright.** (Mech. Eng. 2. pp. 632–634 1898.)—The maximum depth does not exceed 3,400 fathoms. Cables of which the density is reduced by covering each sheath wire with hemp lack durability; the wires (of 90 tons breaking strain) should butt against each other and be covered with thin cotton tape. Aluminium bronze tape $\frac{1}{4}''$ wide (composition not given) is recommended. Existing lines from Australia are summarised and the price per word by the Pacific scheme whether through Canada or United States would be reduced from 6s. to 2s. 6d. M. O'G.

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967. *Higgins' Printing Telegraph Apparatus.* (Electrician, 42. pp. 223–225, 1898.)—A description with detailed drawings is given of the Higgins' type-printing telegraph apparatus. The operator presses down one of thirty-six keys of the transmitter, according to the letter or figure he wishes to signal. This stops a pawl, interrupts the line circuit, and leaves the synchronised

type-wheel of the receiver motionless, with the letter signalled undermost. It also causes the printing-armature to fall back, releases a train of wheels which actuate a sprocket-wheel, and forces the "slip" against the type, thus printing the letter. As the sprock-wheel continues to move the "slip" is automatically drawn away from the type and fed forward. On depressing a key for a subsequent signal, the first key rises, the pawl re-engages with the revolving toothed wheel, the circuit is again completed, the current causes the type-wheel to rotate, the printing armature is at the same time held up until the current is again interrupted by the transmitter pawl, and the cycle is complete. The apparatus is worked by a magneto-machine, operated by a treadle. The speed of signalling is from 25 to 30 words per minute. R. A.

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968. *Multiple Switchboard.* **Dubreuil.** (Électricien, 16. pp. 299–302 and 317–322, 1898.)—A 9,000 subscribers' board is described in general terms. Details of an operator's set are described in the second article. Reasons are given for not having a single central exchange of very large dimensions. M. O'G.

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969. *Switchboard for Toll Lines.* **H. P. Clausen.** (West. Electn. 23. p. 50, 1898.)—Gives diagrams of 4 toll line connections and of the operator's instrument for 10 subscribers. M. O'G.

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970. *Straight "Express" Sectional Switchboard.* (Elect. Rev. N.Y., 33. p. 315, 1898.)—Double circuit cords with ringing and listening circuits normally cut out on both sides are illustrated. Sections of 5 drops are made complete in themselves, no wire being visible at front or back. Any coil is removed by rotating it a quarter turn and withdrawing it from the grip. M. O'G.

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971. *"Express" Telephone System.* **K. B. Miller.** (Amer. Electn. 10. pp. 288–291, 1898.)—Details are given, and a criticism of the necessity for the "B" operators telling the "A" operators which trunk to use. Phonographs are connected in to repeat "Busy; please call again" or "Subscriber does not reply." M. O'G.

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972. *Centralised Sources of Energy in Telephone Exchanges.* **K. B. Miller.** (Elect. World, 32. pp. 679–681, 1898.)—The systems of G. Anders 1881, I. Stone 1882 and 1893, C. Bell 1886, Anthony White 1890, and J. Carty, are described with diagrams. M. O'G.

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973. *London-Birmingham 76/.096 Telephone Cables.* (Elect. Rev. 44. pp. 128–131, 1899.)—The conductors weigh 160 lb. per mile and measure 96 mils. diameter, the resistance per mile at 60° F. is 5·852 standard ohms. The pairs are made up with a lay of 12 in. The arrangement is: Centre, 1 pair; first layer, 6 pairs; second layer, 12 pairs; third layer, 19 pairs. The lead tube is 160 mils. thick and 2·625 diameter. The capacity per mile of each wire with all others to earth is 0·1 mfd. at 50° F. The wire-to-wire of a pair capacity is 0·065 mfd. p.m. The cable is drawn into 3 in. pipes in 150 yard lengths. Illustrations are given of jointing and of the test pillars where dry air may be pumped in.
M. O'G.

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974. *Railway Telephone.* **L. Montillot.** (Électricien, 16. pp. 1–4 and 20–24, 1898.)—A line connects six stations in series. The line is duplicated and earthed at both its extreme ends: by using two lines and the earth, any station can select any other, and any two points by speaking do not prevent any other two from communicating on either side of the first couple. M. O'G.

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975. *Transmitter in Vacuo.* (Elect. Rev. 44. p. 265, 1899.) Kilduchevesky encloses a microphone in a sealed glass chamber, either vacuous or with an inert gas. The currents used may be large without oxidation, and packing does not occur.
M. O'G.

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976. *Eight Subscribers on One Pair of Wires.* **H. Webb.** (Amer. Electn. 11. pp. 30–32, 1899.)—Describes how, by using the earth and polarised relays, the exchange can selectively call up any one of eight without disturbing the other subscribers, and without clock-work. M. O'G.

SCIENCE ABSTRACTS.

PHYSICS AND ELECTRICAL ENGINEERING.

JULY 1899.

GENERAL PHYSICS.

977. *Molecular Theory of Friction of Smooth Bodies.* **M. Brillouin.** (Comptes Rendus, 128. pp. 354–355, 1899.)—It is frequently supposed that the phenomena presented by conservative dynamical systems are essentially reversible. By the following simple example, however, the author shows that such is not always the case. Let a freely suspended needle be acted on by a magnet, and let the latter be slowly rotated; if during a complete revolution of the magnet — corresponding to a complete cycle—the needle is not deflected into any positions of unstable equilibrium, then the energy of the system is the same at the end as at the beginning of a cycle. But if the magnet be placed sufficiently close to the needle to give rise to positions of unstable equilibrium, then, *however slowly the magnet be rotated*, the needle on reaching the first unstable position will suddenly swing round, and begin to oscillate about the next position of stability. The kinetic energy of the oscillation will be retained when the cycle has been completed; reversing the cycle will—so far from reducing the needle to rest—increase its kinetic energy. The cycle is thus irreversible. In the immediate neighbourhood of the surface of a body consisting of isolated molecules the forces exerted by which on an external molecule are functions of the distances, the force-function is either strictly or approximately periodic (according as the body is crystalline or amorphous); hence for an external molecule there will be a large number of positions of stability, separated by positions of instability. So that if the body be moved past the external molecule, the kinetic energy of the latter will be increased by the same amount every time the body advances through a molecular distance. It is therefore evident that the heat developed by the sliding of two polished surfaces pressed against each other is a direct consequence of the molecular theory, and not a contradiction of it.

A. H.

978. *Fluid Motion.* **H. S. Hele-Shaw.** (Engineering, 67. pp. 28–30, 1899.)—The motion studied takes place between two parallel sheets close together. Stokes has proved mathematically the very remarkable fact that, under these conditions, the lines of flow are the same as would be given by a perfectly frictionless or viscid liquid. The author shows the stream lines experimentally, under various interesting conditions, by introducing coloured liquid at suitable points. The paper contains some fascinating reproductions of photographs. A. Gs.

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979. *Speed Indicator.* **W. H. Browne, Jr.** (Electricity, N.Y., 15. p. 35, 1898.)—This instrument, made by the Weston Electrical Instrument Company, comprises a small permanent magnet dynamo with a carefully laminated drum-wound armature, which works with flat side-bearing copper brushes so as to permit rotation in either direction, longitudinal motion of the armature being prevented by set collars. The armature spindle is connected to the machine, a dynamo for example, whose speed it is desired to measure, by means of a flexible "dentist's" shaft of sufficient length to remove the indicator from the magnetic field of the dynamo, the other end of the flexible shaft having a split externally roughened pin which can be pushed into a hole in the end of the dynamo shaft. The instrument is connected to a high resistance voltmeter, and, by properly setting the brushes, a straight-line characteristic can be obtained for either right or left-handed rotation. An accuracy of one revolution in 1,500 can be obtained. It has worked satisfactorily for nine months at the University of Nebraska. C. K. F.

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980. *Interferential Measurement of Length and Thickness.* **A. Perot** and **C. Fabry.** (Annal. Chim. Phys. 16. pp. 289–338, 1899.)—During the past two years the authors have published many papers on this subject, all more or less dealing with special applications of the principle. The present paper is more complete, and is useful in that cross references are given to the papers of other workers in the same direction. C. P. B.

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981. *Physical Properties of Metals.* **H. F. Parshall** and **H. M. Hobart.** (Engineering, 66. p. 869, 1898.)—The authors give a table of results by various observers of specific resistance, temperature coefficient of resistance, specific heat, tensile strength, and specific gravity of a large number of metals and alloys.

W. R. C.

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982. *Compressibility of Colloids.* **C. Barus.** (Amer. Journ. Sci. 6. pp. 285–298, 1898.)—The author has investigated the compressibility of colloids in order to throw some light on the elastic properties of glass, geologically considered, and the jelly theory of the ether. In general, colloidal solutions of gelatine and albumen in water have a compressibility very nearly the same as that of water, but without the increase with temperature definitely indicated in the case of water. Some curious phenomena were observed by the author when compressing colloids in a capillary tube by means of a mercury column.

When pressure continually increases (very gradually), the meniscus passes into a conoidal form, thence into an unstable figure, from which presently a drop is shot off, upward. This exceedingly minute projectile may penetrate the whole column of coagulated colloid, 13 cm. or even 20 cm. long. The phenomenon repeats itself at consecutive intervals even at constant pressures. With the 10 per cent. gelatine coagulum, on one occasion, he counted twelve of these little projectiles (on another thirteen, &c.), each less than $\frac{1}{10}$ mm. in diameter and disposed at regular intervals, *i.e.*, nearly equidistant in the axis of the column of coagulated (solid) colloid. The top one rose 12 cm. through the medium and against gravity, the lowest about 1 cm. above the meniscus. On removing pressure five of them gradually dropped back upon the meniscus, which in the telescope soon resembled a bunch of silver grapes. When the tube is allowed to stand vertically overnight with pressure removed, all drops often fall out of the colloidal column before morning. This motion of droplets, up or down, is equally evident to the naked eye.

The phenomenon of the electric spark and the above experiments on the breakdown of mechanical strain as evidenced by the motion of the mercury projectiles are closely analogous. In both cases, there is an originally continuous and solid medium. When breakdown occurs there is in each case motion into the continuous strained medium, through the channel of broken-down, discontinuous, or triturated medium left in the wake. Finally there is recementation resulting in a new continuous medium. We may distinguish between the same solid jelly-like medium in the continuous and in the discontinuous or triturated state, in the sense pointed out above; the former transmits stress like a solid locally, showing rigidity, whereas the latter transmits it like a liquid, and in proportion as the degree of discontinuity is greater, virtually imparts hydrostatic stress. *The same ether may therefore act, as the case may be, either as a liquid or a solid*, just as, in the above experiments with gelatine, one and the same originally continuous and homogeneous body manifests itself in both rôles, under the same conditions. E. E. F.

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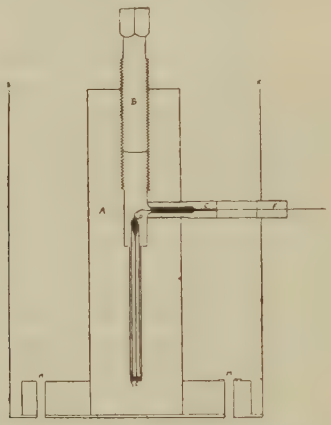
983. *High-Pressure Piezometer.* **A. de F. Palmer.** (Amer. Journ. Sci. 6. pp. 451–454, 1898.)—An apparatus for measuring

very high pressures may be based upon the known relations between the electrical resistance of mercury and the pressure upon it. The apparatus is shown in the diagram, where A is a Bessemer steel cylinder firmly keyed to a cast-iron collar having holes, H H, for anchor bolts. D is a capillary glass tube, 0·1 mm. in internal diameter and 8 cm. long, filled with pure mercury electrically connected with A by a globule of mercury E. A platinum electrode, sealed into the top of D, is soldered to a silk-covered copper wire that passes out of A through a marine



glue plug in the tinned steel screw, C, and forms the upper connection with a Wheatstone's bridge. Pressures may be obtained and measured up to 3,500 atmospheres. E. E. F.

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984. *Action of Electric Currents on Photographic Plates.* **E. Jahr.** (Elektrochem. Ztschr. 5. pp. 197–199, 1899.)—The action of an electric current on a gelatino-bromide dry plate immersed in the developing liquid is observed even with a closed circuit, and increases in intensity with the current and with the E.M.F. The effects are similar to those previously described as being produced by magnetism (see 1899, Abstract No. 837), and cannot well be explained without the accompanying figures.

N. L.

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985. *Experimental Reproduction of Phenomena Exhibited by Comets.* **T. Bredichin.** (St. Petersburg Acad. Sci. Bull. 8. pp. 173–189, 1898.)—Goldstein has advanced the theory that the tails of comets do not, as is generally supposed, consist of matter thrown out by the head, but that they are luminous phenomena excited in the space surrounding the head by kathode

rays emitted by the sun. This theory is based on certain experiments carried out with kathode rays which closely resemble some of the appearances presented by comets. The author critically examines the new theory, and concludes that it does not rest on a sufficiently sound experimental basis. A. H.

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986. *Enhanced Lines in Spectrum of α Cygni.* **N. Lockyer.** (Roy. Soc. Proc. 64. pp. 320–322, 1899.)—In previous communications to the Royal Society (Roy. Soc. Proc. 60. p. 475; 61. p. 148; 61. p. 441) the author has described how many of the lines in α Cygni have been found to be due to terrestrial substances, but hitherto unknown because their spectra have only been examined under certain conditions. It is found that when the spectra of the metals, &c., are examined under varying conditions of temperature, such as the oxyhydrogen flame, electric arc and induction spark, certain lines are common throughout, but there are also others which only appear at the higher temperature of the spark. It was pointed out in the earlier papers that the metallic lines in α Cygni were almost entirely these "higher temperature" or "enhanced" lines, the arc lines being exceedingly weak or entirely absent. In August, 1898, the laboratory at South Kensington was enriched by the loan of the large Spottiswoode induction coil, capable of giving a 40-inch spark. With this coil, in conjunction with a very large condenser in parallel on the secondary circuit, the discharge is so luminous that it has been found possible to photograph the spectra under much larger dispersion than before, and this separation of many of the lines from the accompanying gaseous lines renders their measurement more accurate and their detection easier. The elements which have thus far been re-examined are Fe, Mg, Ca, Si, Sr, Va, Ti, Ni, Mn, Cr, Co, Cu. The present state of the problem may be summed up by saying that out of the 307 lines which have been measured in the spectrum of α Cygni between λ 3798·1 and λ 4861·6, 120 coincide with enhanced metallic lines. If, however, only the strongest lines be considered, out of the 40 lines in α Cygni which are over intensity 4 (strongest line in spectrum = 10), 38 are found to have enhanced line representatives. A map of the spectrum of α Cygni showing the lines which have these recently discovered terrestrial coincidences accompanies the paper. C. P. B.

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987. *Photographic Spectra of Northern Stars.* **F. McClean.** (Phil. Trans. 191. pp. 127–138, 1898.)—This paper contains the discussion of the spectra of 160 stars, including all stars equal to and brighter than the $3\frac{1}{2}$ magnitude, which are visible from the south of England. The photographs have been obtained by the author with a prismatic camera at his observatory at Rusthall.

The whole celestial sphere has been divided into 8 zones, defined with reference to the Galactic plane, and the spectra here discussed fill up 5 of these zones. Reproductions of all the spectra are given with the paper, those in each zone being arranged according to the types suggested by Secchi; Type I, however, being farther subdivided into three parts. The arrangement of the stars in each zone is therefore as follows:—

I. Hydrogen and Helium stars. II. Hydrogen stars. III. Hydrogen and Iron stars. IV. Solar stars. V. Banded spectra, Duner's III.*a*. VI. Fluted spectra (probably Carbon), Duner's III.*b*.

Of special importance is the author's suggestion that certain outstanding lines in the spectra of stars of Division I. might be due to oxygen. This has since been definitely confirmed by the photographs of stellar spectra obtained at South Kensington and Cape of Good Hope (see 1898, Abstract 1208).

Tables showing the characteristics of all the spectra are given, with cross references to the physical classification allotted to them by other authorities, Lockyer, Pickering, Vogel, and Secchi.

C. P. B.

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988. *Spectrum and Radial Velocity of α Aquilæ.* **H. C. Vogel.** (Berlin Akad. Sitzber. 46. pp. 721–734, 1898.)—α Aquilæ (Altair) is a star having a peculiar spectrum in that all the lines are diffuse. This is commonly explained by supposing the star to be in such rapid rotation on its axis as to cause the spectral lines to be displaced to the red and violet from their true position as explained by Doppler. In addition to the characteristic strong series of Hydrogen lines which place the star in the 1st class, however, Scheiner called attention in 1889 to the presence of fainter but also diffuse bands which agreed in position with "groups of lines" in spectra of stars of the 2nd type (for example, the sun).

To account for this, he put forward two views: one that the effect might be one of the stages of evolution of the star, the other that the star may be a binary, one component being of the 1st class, the companion of the 2nd.

Evidence as to the duplicity of the star was sought by means of photography, both at Potsdam by the author, and at Paris by H. Deslandres, but the results were so discordant in themselves that no definite conclusion could be obtained from them. Vogel, however, had a new series of spectrograms made in 1896 and 1897 with better apparatus, and it is on the measurement of 29 of these that his conclusions are now drawn. The faint diffuse bands described by Scheiner are well shown, and to account for their diffuseness, Vogel made experiments with the solar spectrum by widening the slit, imperfect focussing, &c., and finally thinks that the cause of their appearance in α Aquilæ is really owing to the running together of neighbouring lines owing to their being

broadened. Then the question of how the broadening is caused comes forward. Besides the possibility of this being due to motion of the star in the line of sight owing to rotation, we know from laboratory experience that varying conditions of density, temperature, and pressure greatly affect the breadth of spectral lines.

As it has been impossible to detect a periodic motion of the star, it is unlikely that it is a binary, and after many conjectures the following are the author's conclusions: (1) The spectrum really belongs to class I.*a*, 3; (2) the hydrogen lines are broadened by the particular conditions of temperature and pressure of the star, and also by its rotation; (3) in addition, the *atmosphere* of the star contains many metallic lines and tends to resemble stars of class II.*a*; (4) All lines being broadened by rotation, the fine close lines will form faint diffuse bonds, while the strong isolated lines will be diffuse.

A velocity of about 27 kilometres would account for the observed broadening.

The paper concludes with a discussion of the observations made for the radial velocity in the line of sight during 1896 and 1897, for which the mean value is determined to be

$$-32{\cdot}9 \text{ km.} \pm 0{\cdot}3 \text{ or } -4{\cdot}4 \pm 0{\cdot}04 \text{ geographical miles.}$$

The minus sign indicates that the spectrum is displaced to the violet from the normal, and corresponds to the approach of the star towards the earth. C. P. B.

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989. *Telluric Lines in Solar Spectrum.* **A. de la Baume-Pluvinel.** (Comptes Rendus, 128. pp. 269–274, 1899.)—The series of doublets constituting the B group of the solar spectrum have been proved by Janssen to be due to atmospheric oxygen, by his observations taken between the Eiffel Tower and his observatory at Meudon, and from the summit of Mont Blanc. These observations, however, were only visual, and at the suggestion of Janssen, Baume-Pluvinel repeated the work photographically. The spectrograph was one of considerable power, its components being as follows: The spectrum was obtained by a 4-inch Rowland plane-grating, having a ruled surface 8 cm. × 5 cm. with 14,438 lines to the inch (568 to the mm.). The collimator and camera lenses had focal lengths of 1·10 m. and 1.50 m. respectively, the aperture of each being 0·108 m. A condensing lens, 0·85 m. focal length, fed with light from a heliostat, produced an image of the sun 7·6 mm. diameter on the slit plate. The overlapping of other spectra than the one to be photographed was obviated by a cell containing a solution of aurine placed in front of the slit. Plates of medium rapidity only could be used (the grain of fast plates being too coarse), and these were sensitised for the red by immersion in a bath of cyanine. Well exposed plates

were obtained by 30 minutes' exposure, using the second order spectrum.

Observations were made at Chamounix and on the summit of Mont Blanc on the 5th and 6th of September, 1898. A reproduction is given from the photographs of the B group showing their relative intensity at Paris, Chamounix, and Mont Blanc, which quite well shows their gradual decrease in intensity at the three stations.

The persistence of the lines at the summit of Mont Blanc, at an altitude of 4,810 m., confirms the statement of Janssen that a column of oxygen 120 m. long at atmospheric pressure would suffice to give the bands. The author calculates how high it would be necessary to ascend before the remaining layer of oxygen became less than this amount, and finds it to be at an altitude of about 21,500 m., the pressure being reduced to 53 mm. If it is possible to equip a balloon with an automatic spectroscopic apparatus this question may be settled by a solar spectrum being photographed without the presence of this particular group of lines.

The paper concludes with several observations and suggestions for future work on the matter by M. Janssen. C. P. B.

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990. *Three Types of Stellar Spectra.* **A. Muller.** (Revue Scientif. 11. pp. 238–242, 1899.)—This is a somewhat popular article, reviewing the growth of stellar spectroscopy, and interesting in that it contains descriptions of much more than is implied in the title. The types of spectra, however, are not brought up to date by any means, nor are the sub-divisions into which Secchi and Vogel classified them taken into consideration. C. P. B.

LIGHT.

991. *Reflection of Light.* **A. Lafay.** (Journ. de Physique, 8. pp. 96–100, 1899.)—The author shows how ready-reckoning scales may be made to show, given the incidence and the index of refraction of the refracting glass, what are the intensities of the reflected and refracted rays and what are the respective proportions of the polarised lights in each. A. D.

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992. *Metallic Reflection.* **E. Hagen** and **H. Rubens.** (Berlin Phys. Gesell. Verh. 17. pp. 143–147, 1898.)—The method employed facilitates the measurement of reflective power when the incidence is very nearly vertical, thus eliminating the errors due to polarisation. The reflection is not measured in its total extent, but for the separate colours by means of a spectro-photometer and Maxwell's eye-piece slit. The metals are examined in the shape of concave mirrors, near the centre of curvature of which a glowing platinum wire is mounted. An image of both the wire and its real image is projected upon the double slit of the spectro-photometer, so that the two can be directly compared.

The results are given in the following table, where the figures denote the percentage of light of various wave-lengths reflected by the metals in question :—

For λ =	450	500	550	600	650	700 $\mu\mu$
A. Pure metals—						
Silver	90·6	91·8	92·5	93·0	93·6	94·6
Platinum	55·8	58·4	61·1	64·2	66·3	70·1
Nickel	58·5	60·8	62·6	64·9	65·9	69·8
Steel, hardened	58·6	59·6	59·4	60·0	60·1	60·7
Steel, unhardened	56·3	55·2	55·1	56·0	56·9	59·3
Gold	36·8	47·3	74·7	85·7	88·2	92·2
Copper	48·8	53·3	59·5	83·5	89·0	90·7
B. Speculum metals—						
Alloy of Ross (68·2 p.c. Cu + 31·8 Sn)	62·0	62·9	64·0	64·4	65·6	68·1
Alloy of Brashear (do.)	,,	,,	,,	,,	,,	,,
Alloy No. 1 of Schröder (66 p.c. Cu + 22 Sn + 12 Zn)	62·4	62·5	63·4	64·2	65·1	68·0
Alloy No. 6 of Schröder (60 p.c. Cu + 30 Sn + 10 Ag)	61·5	62·5	63·6	65·2	66·6	68·6
C. Glass mirrors—						
Backed with silver .....from	79·3	81·5	82·5	82·5	83·5	84·5
,, ,, ...to	85·7	86·6	88·2	88·1	89·1	89·6
Backed with amalgam	72·8	70·9	71·2	69·9	71·5	72·8

The reflective power increases in general with the wave-length, especially in the case of gold and copper. Iron shows a minimum at 550 $\mu\mu$. E. E. F.

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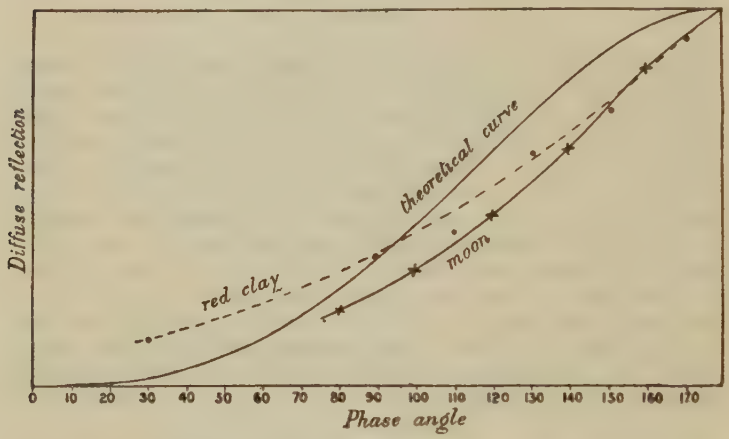
993. *Irregular Reflection.* **C. C. Hutchins.** (Amer. Journ. Sci. 6. pp. 373–380, 1898.)—The reflecting powers of various dull surfaces were studied by means of the thermograph, so as to obtain the total energy reflected. The source of light was the sun. The diagram shows the reflection from a sphere of red



clay and from the moon at various phase angles, as compared with the reflection postulated by Lambert's law. The following table shows the albedo of various bodies investigated:—

	Albedo.
Plaster	92·7
Magnesia	47·6
Paper	82·6
Green leaf, upper side	30·2
Green leaf, under side	38·0
Volcanic rock	27·4
Brown soil	31·7

E. E. F.

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994. *Brightness of Sources of Light.* **P. Jenko.** (Wied. Annalen, 66. 5. pp. 1182–1185, 1898.)—Taking as unity the intrinsic brightness of a sheet of Bristol cardboard illuminated by a standard candle at 1 metre distance, that of a candle-flame itself is from 12,000–22,000; a kerosene lamp-flame, 97,000; Violle's unit (platinum at its melting-point), 1,008,000. Several white surfaces were compared, and magnesium carbonate found

to be the best for photometric purposes, because its brightness was the highest and it was most completely free from regular reflexion. R. A. L.

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995. *Interference Microscope.* **E. Pringsheim.** (Berlin Phys. Gesell. Verh. 17. pp. 152–156, 1898.)—An adaptation of Jamin's refractometer for microscopic work, as first described by Sirks, has been constructed for medical purposes. Jamin's plane-parallel plates are replaced by slightly wedge-shaped plates, which produce a system of interference fringes lying geometrically midway between them. These and the object whose refractive index is to be determined are seen simultaneously in the field of the microscope, and the displacement of the fringes is used for measurement. In practice the displacement is compensated by a body of known refractive index. E. E. F.

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996. *Inductoscripts.* **J. A. McClelland.** (Cambridge Phil. Soc. Proc. 9. pp. 522–525, 1898.)—The formation of figures on photographic plates by electric discharges may be explained either by direct chemical action, or by chemical action due to light. If the figures are produced by direct chemical action it would point to a difference in the manner in which the positive and negative discharges spread over the plate. If produced by the action of light, the figures would follow the different forms of discharge in the air close to the plate. The author investigates the effect of changing the gaseous medium surrounding the discharging point, and the result of interposing thin plates of different material between the film and the spark. He concludes that the inductoscript is produced principally by the light of the discharge. With a thin plate of mica or glass on the film, the branching lines of the positive figure are only slightly less distinct than when the film is uncovered. When one-half of the thin glass plate is painted black, to make it opaque, the figure is formed only on the portion of film under the transparent half of the cover. Inductoscripts of coins placed on the film can be obtained even with an ebonite plate between the coins and the discharge point; in this case the effect is due to the induced charge. But no effect is produced when the ebonite is between the coins and the film. That the positive and negative figures differ so radically is ascribed to the different forms of discharge in air, in the two cases—positive brush, negative glow. The various results obtained are illustrated. R. A.

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997. *Rotatory Power of Electrolytes in Dilute Solution.* **E. Rimbach.** (Zeitschr. Phys. Chem. 28. pp. 251–256, 1899.)—Careful measurements are made of the rotatory powers of dextro-rotatory mandelic acid and of its sodium salt. The

specific rotation of the latter is represented by the formula $[\alpha]_D^{20°} = +141{\cdot}23 - 0{\cdot}39796\,q$, where q is the percentage of water in the solution. For mandelic acid, however, the linear formula $[\alpha]_D^{20°} = +212{\cdot}52 - 0{\cdot}5777\,q$ only holds good for solutions containing more than about 3 per cent. of the acid. In more dilute solutions the rotation diminishes much more rapidly. This difference between the two substances corresponds with the fact that whilst the ionisation of the sodium salt is far advanced in the stronger solutions, and therefore changes but little on dilution, that of the free acid is still far from complete even in the most dilute solutions examined. T. E.

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998. *Rotary Dispersion.* **G. V. Wendell.** (Wied. Annalen, 66. 5. pp. 1149–1161, 1898.)—The rotary dispersion in tartaric acid and in oil of turpentine are here experimentally studied. The specific rotation is determined in aqueous solutions of various strengths of tartaric acid for each of the lines C, D, E, *b* and F, for each 5° temperature between 0° and 50° C. The results are given in tabular form, and some are plotted in curves.

The specific rotations of mixtures of right and left-handed oil of turpentine are measured and found to agree closely with those calculated by Biot's formula, the calculated values, however, being always slightly greater. J. B. H.

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999. *Anomalous Dispersion of Incandescent Sodium Vapour.* **H. Becquerel.** (Comptes Rendus, 128. pp. 145–151, 1899.)—The author studies the anomalous dispersion by photographing side by side on the same plate a normal spectrum, and the same as deviated by refraction in a prismatic flame containing sodium vapour. The deviation (vertical) y is plotted as a function of x (distance from D_1 or D_2), and it is found that the results can be represented by a formula of the type—

$$y = \frac{k_1}{x} + \frac{k_2}{x - a}$$

where a = distance $D_1\,D_2$. Between the rays D_1 and D_2 the deviation-curve possesses a point of inflexion, while beyond D_1 and D_2 on either side it consists of portions of a hyperbola. For waves with vibration-frequencies slightly higher than D_1 or D_2 the corresponding indices of refraction are found to be negative, *i.e.*, these waves travel faster in the sodium vapour than in a vacuum.

The author shows finally how this anomalous dispersion, taken in conjunction with the Zeeman effect, will serve to explain the phenomenon predicted and observed by Voigt (Gött. Nachrichten,

November 26, 1898), viz., that a sodium flame placed in a magnetic field and traversed by a beam of polarised light exhibits double refraction in a direction perpendicular to that of the magnetic field.

F. G. D.

1000. *Radiation Phenomena in a Magnetic Field.* **T. Preston.** (Phil. Mag. 47. pp. 165–178, 1899.)—The author continues his remarks on the experiments carried out in strong magnetic fields. He considers that Larmor's electromagnetic theory furnishes an explanation of the results obtained. Consider the simple case of a single ion describing an elliptic orbit under a central force directly proportional to the distance: this electric charge, under the action of a magnetic field, has its elliptic orbit forced into precession round the direction of the magnetic force, this being a first approximation. If N be the natural frequency of revolution of the particle in its orbit and n the frequency of revolution of the orbit in its precessional movement, the combined movement is equivalent to the coexisting motions of frequencies $N+n$, N, and $N-n$ respectively. When n is small compared with N, so that its square may be neglected, the equations of motion of the particle in the revolving orbit become identical with those of the moving ion in the magnetic field. This simple theory predicts that a single spectral line should be converted into a triplet by the action of the magnetic field, and that the constituents of this triplet should be plane polarised when viewed across the lines of force. It explains the cause of the tripling as the forced precession of the ionic orbits round the lines of magnetic force, and it assigns a dynamical cause for this precession in the action of the magnetic field on the ionic charge moving through it.

Stoney gave the explanation of the phenomena in 1891, six years before the effects were observed. His aim was to explain the occurrence of doublets and equidistant satellites in the spectra of gases, without reference to the influence of a magnetic field, which was not then known to exist. He considered what the effect would be on the period of the radiations from a moving electron if subject to disturbing forces. Perturbations seem clearly to be sufficient to account for all the phenomena. Still, Stoney's explanation of natural doublets is subject to serious difficulty, from the fact that the two lines of a given doublet behave in different ways, as if they arose from different sources rather than from the perturbation of the same source.

According to the electromagnetic theory, the separation, $\delta\lambda$, of the side lines of a magnetic triplet should vary directly as λ^2 as we pass from line to line of the same spectrum. It is possible that the lines of any one substance may be thrown into groups for each of which $\delta\lambda$ varies as λ^2, each of these groups being produced by the motion of a single ion. The number of different kinds of ions in the atom or molecule may thus be determined. Investigation, so far as carried, confirms this speculation. The

quantity e/m or $\delta\lambda/\lambda_2$ is the same for corresponding lines in homologous spectra, and moreover the *character* of the magnetic effect is also the same for corresponding lines. J. J. S.

1001. *Uranium Radiation.* **E. Rutherford.** (Phil. Mag. 47. pp. 109–163, 1899.)—The nature of the radiation emitted by uranium and its compounds has been investigated with special reference to the electrical conduction produced. Very similar effects are produced in gases by uranium and Röntgen radiation. The author finds no evidence to show that polarisation or refraction takes place: in this respect he differs from Becquerel, the discoverer of the uranium radiation, who concludes that polarisation and refraction do occur. The theory of ionisation, which supposes that the rays in passing through a gas produce positively and negatively charged particles in the gas, and that the number produced per second depends on the intensity of the radiation and the pressure, furnishes a satisfactory explanation of the electrical conductivity produced by uranium radiation.

Experiments are described which show that uranium radiation is complex: in it there are present at least two distinct types of radiation—one that is very readily absorbed, called by the author the α radiation, and the other of a more penetrative character, termed the β radiation. There are indications that the β radiation is approximately homogeneous; this type passes through the substances tried with greater facility than the α radiation. In experiments with different uranium compounds it was found that the amount of the α radiation depended chiefly on the surface of the uranium compound, while the β radiation depended also on the thickness of the layer. The rate of leakage of electricity between two metal plates kept at different potentials and placed 4 cm. apart, on one of which metallic uranium or a compound of uranium was spread, was measured by means of an electrometer. The rate of leakage due to the β radiation is, as a rule, small compared with that produced by the α radiation. The α radiation is strongly absorbed by gases, while the β radiation is only slightly so. In the case of photographic action it is found that the β radiation is the effective variety. There is a great difference in the power of penetration of the two types of radiation. The transparency of aluminium for the β radiation is over 100 times as great as for the α radiation. The opacity of the metals aluminium, copper, silver, platinum for the β radiation follows the same order as their atomic weights. Platinum has an opacity 16 times as great as aluminium. The α radiation from uranium and its compounds is rapidly absorbed in its passage through gases. The absorption for hydrogen, air, and carbonic acid was determined, and was found to be least in hydrogen and greatest in carbonic acid. The results obtained on the variation of leakage with distance may be simply interpreted on the theory of ionisation

of the gas through which the radiation passes. The absorption of the β radiation is comparatively slight. The absorption of the α radiation increases with increase of pressure and very approximately varies directly as the pressure. In one experiment it was found that the rate of leakage between two plates reached a maximum when the gas was at a pressure of less than half an atmosphere and then decreased ; at 10 cm. pressure the rate of leakage was still greater than at atmospheric pressure. The rate of leakage increases at first with diminution of pressure. There appears to be approximately the same amount of ionisation in all gases for the same absorption of energy. On comparing the velocities of the ions under similar conditions, in Röntgen and uranium conduction, it appears that the ions in the two types of conduction are the same.

The cause of the radiation continuously emitted by uranium and its salts remains unknown. The results hitherto obtained point to the conclusion that uranium gives out types of radiation which, as regards their effect on gases, are similar to Röntgen rays and the secondary radiation emitted by metals when Röntgen rays fall upon them. J. J. Thomson has suggested that the regrouping of the constituents of the atom may give rise to electrical effects such as are produced in the ionisation of a gas. The energy spent in producing uranium radiation is probably extremely small, so that the radiation could continue for long intervals of time without much diminution of the internal energy of the uranium.

J. J. S.

1002. *Radio-active Bodies.* **H. Becquerel.** (Comptes Rendus, 128. pp. 771–777, 1899.)—The author's earlier experiments, according to which uranium rays were regularly polarised, reflected, and refracted to some extent, are not confirmed by later experiments on uranium, thorium, radium, and polonium compounds. The reflection, according to the more recent photo-plate *clichés*, seems to be diffuse and to be complicated with secondary radiations ; but it remains unexplained why the earlier *clichés* came out as they did. Radiations from polonium are much absorbed by paper and mica, quartz and spar, while those from radium are much less so. The uranium preparations of May, 1896, have lost very little of their radio-active power. Such substances seem, like a magnet, to contain a store of energy expended in giving them their present condition ; and, as in some substances rendered phosphorescent by heat, the process of giving out this energy, though constant for some years, is very slow. It has not been found possible by any physical means to bring about any appreciable variation in the intensity of the radiation emitted.

A. D.

1003. *Absorption of Röntgen Rays.* **J. H. Gladstone** and **W. Hibbert.** (Chem. News, 78. pp. 199–200, 1898 ; Rep. Brit.

Assoc. 1898, pp. 835–836.)—Further experiments, confirming the conclusion (Brit. Assoc. 1896, 1897) that absorption of Röntgen rays by a compound body is almost wholly dependent upon the absorption exercised by its constituents and is little, if at all, modified by their physical condition, or by change of atomicity, or by other differences of combination. The small differences of result—*e.g.*, uncombined carbon absorbing a little more than an equivalent quantity of any of the hydrocarbons—may be due to the presence in the Röntgen radiations of small quantities of rays which, though they have passed through aluminium foil, have properties somewhat analogous to ordinary light. A. D.

1004. *Transformations of Röntgen Rays.* **Hurmuzescu.** (Comptes Rendus, 128. pp. 422–425, 1899.) (See 1898, Abstract No. 1132, and 1899, Abstract No. 431.)—There appears to exist a relation between the emission of rays transformed by a given body and their absorption by the same body, the rays being absorbed more readily by it than by other bodies. This selective absorption manifests itself in the discharging effect produced by the transformed rays. Two electroscopes identical in every respect, except that the cage of one consisted of zinc and that of the other of lead, were charged to the same potential, and subjected to the action of rays transformed by lead (the transformed rays alone being allowed to enter the cage, and not the X-rays producing them). It was found that the time required to diminish the deflection of the zinc-cage electroscope by a certain amount was 29·8 secs., while the time for the lead-cage electroscope was 51 secs. These phenomena point to the fact that the effects produced are due to a transformation of the X-rays (into rays of greater wave-length), and not to simple diffusion. A. H.

1005. *Transformation of Röntgen Rays by Matter.* **G. Sagnac.** (Écl. Électr. 18. pp. 41–48, 1899.)—An interesting *résumé*, with polemical digressions, of the author's work on this subject and that of others. A. D.

HEAT.

1006. *Dilatation of Perfect Gases.* **D. Berthelot.** (Comptes Rendus, 128. pp. 498–500, 1899.)—The author discusses the coefficient of dilatation at constant pressure, denoted by γ, common to gases. The generally accepted value has been $1/\gamma = 273{\cdot}14$. Some of the German physicists have recently, says the author, proposed to raise this figure to 274, or even 274·5. He refers to recent researches of Chappuis, Amagat, Leduc, and Sacerdote, made with regard to hydrogen under pressures from 1 millimetre of mercury to 100 atmospheres. These, he says, restore the classical number 273·14, or 273. Some interesting relations are mentioned arising from the fact that for hydrogen γ in the perfect gas is greater, for other gases less, than α, the corresponding coefficient under atmospheric pressure. S. H. B.

1007. *Characteristic Equation for Fluids.* **E. H. Amagat.** (Comptes Rendus, 128. pp. 538–542, 1899.)—A new form of the characteristic is arrived at for carbonic acid, viz.:—

$$\left[p + \frac{v - T\left\{ a + m(v-b) + c(v-b)^{-1} \right\}}{kv^r - \alpha + n\sqrt{\left\{ (v-\beta)^2 + d^2 \right\}}} \right] v = RT,$$

where—

$a = 0{\cdot}00000014566$	$R = 0{\cdot}00368$	$\alpha = 0{\cdot}000000198$
$b = 0{\cdot}000947$	$k = 44{\cdot}6$	$\beta = 0{\cdot}0018425$
$c = 0{\cdot}0000000028832$	$r = 2{\cdot}85$	$d = 0{\cdot}0002679$
$m = 0{\cdot}0018$		$n = 0{\cdot}0006$.

The history of the construction of this formula, which satisfactorily represents the results obtained with pressures varying from 1 to 1000 atmospheres and temperatures ranging from 0° to 258°, is given at length. R. E. B.

1008. *Regnault's Calorie and the Specific Volumes of Steam.* **G. P. Starkweather.** (Amer. Journ. Sci. 7. pp. 13–33, 1899.)—Regnault's determination of the specific heat of water and the total heat of steam, together with the results of ten other experimenters, are first discussed at length. It is found that Regnault's thermometric scale was that of the air-thermometer; that his calorie represents the specific heat at 15° on this scale; that with this unit his experiments give 1·00358 for the mean specific heat between 0° and 100°, and for the "heat of water,"

$$h = t + 0{\cdot}00000929\,t^2 + 0{\cdot}000000265\,t^3 \quad \text{above } 100°$$
$$= 1{\cdot}00449\,t - 0{\cdot}0001904\,t^2 + 0{\cdot}00000181\,3\,t^3 \quad \text{below } 100°;$$

that the "total heat of steam" is best represented by

$$H = 603{\cdot}2 + 0{\cdot}356\,t - 0{\cdot}00021\,t^2 \quad \text{above } 100°$$
$$= 598{\cdot}9 + 0{\cdot}442\,t - 0{\cdot}00064\,t^2 \quad \text{below } 100°.$$

The difference between these quantities gives the latent heat, from which, with Rowland's value of J, viz., 427·03 kgm. at Paris at 15°, the following values of the specific volumes of dry saturated steam have been calculated:—

0°	208·94	...	...	...	...	...	...
10	107·88	60	7·6703	110	1·1973	160	0·30278
20	58·505	70	5·0320	120	0·88099	170	0·23982
30	33·198	80	3·3942	130	0·65948	180	0·19216
40	19·637	90	2·3464	140	0·50152	190	0·15566
50	12·063	100	1·6587	150	0·38707	200	0·12739

The error of these numbers cannot be more than 0·5 per cent. on the score of the value of J, nor more than 0·6 per cent. at 200°, 0 per cent. at 100°, 0·5 per cent. at 0° from uncertainty as to the latent heats; below 40° the numbers are entirely uncertain, owing to errors in Regnault's values of p and dp/dt.

The volumetric experiments on superheated steam made by ten observers, in which an unusual amount of difficulty occurs by reason of condensation on the walls of the containing vessel, are then minutely discussed with the conclusion "that all our knowledge concerning the density of steam is limited to the saturation line, the experiments on superheated steam presenting discrepancies which cannot be reconciled." R. E. B.

1009. *Thermometric Fixed Point and Normal Temperature.* **W. Meyerhoffer** and **A. P. Saunders.** (Zeitschr. Phys. Chem. 27. pp. 367–368, 1898.)—The transition-temperature of Na_2SO_4 is lowered from 32·35° to 17·9° by admixture with NaCl in the proportion of their molecular weights. This lower point is convenient to take as a *normal* "temperature of the room," being easily and cheaply attained and lying within the range of room-temperatures ordinarily occurring. R. E. B.

1010. *Transition-temperatures as Thermometric Fixed Points.* **T. W. Richards** and **J. B. Churchill.** (Amer. Acad. Proc. 34. pp. 277–280, 1899.)—The authors claim priority over Meyerhoffer and Saunders (see preceding Abstract) in suggesting this use of transition-temperatures. As normal temperature for graduating flasks, &c., they prefer one nearer 20° than 18°, at least for America, such, indeed, as is given by sodium chromate

(19·6°). They have determined the following transition-temperatures on the hydrogen thermometer, but give them only as approximations subject to future revision. (On the mercury thermometer the temperatures are 0·105 higher.)

Sodic chromate.....	$Na_2CrO_4 . 10 H_2O$	19·6
Sodic sulphate	$Na_2SO_4 . 10 H_2O$	32·379
Sodic carbonate	$Na_2CO_3 . 10 H_2O$	35·1
Sodic thiosulphate ...	$Na_2S_2O_3 . 5 H_2O$	48·0
Sodic bromide	$NaBr . 2 H_2O$	50·7
Manganous chloride...	$MnCl_2 . 4 H_2O$	57·8
Strontic chloride	$SrCl . 6 H_2O$	61·0
Sodic phosphate	$Na_3PO_4 . 12 H_2O$	73·4
Baric hydroxide	$Ba(OH)_2 . 8 H_2O$	77·9

R. E. B.

1011. *Platinum Thermometry.* **H. L. Callendar.** (Phil. Mag. 47. pp. 191–222, 1899.)—In this paper a historical summary is given of the work which led up to the employment of platinum thermometers. Various formulæ and methods of reduction are discussed and the author explains his proposed standard notation and nomenclature. J. J. S.

1012. *Platinum Thermometry.* **E. B. H. Wade.** (Cambridge Phil. Soc. Proc. 9. pp. 526–529, 1898.)—In the method adopted by Callendar and Griffiths for measuring temperatures by platinum thermometers, equal increments of resistance do not represent equal increments of temperature; the equation connecting resistance with temperature is by them assumed to be a parabola with inclined axes, and this involves rather troublesome calculations. The author shows that the bridge can be arranged in such a manner as to avoid these calculations. The fixed arms of the bridge are chosen equal to one another. The adjustable arm consists of two sets of coils in parallel, and by whatever amount the resistance of one set is increased that of the other is diminished; their series resistance is therefore constant. It is proved that, under these conditions, if this series resistance is rightly chosen, the bridge-readings are now linear functions of the temperature.

Incidentally, the author points out a curious analogy between the action of such a shunt and the action of impurities in a wire. It is regarded by many as not improbable that in a wire of perfectly pure platinum the resistance might be a linear function of the temperature: no shunt would then be necessary to give direct bridge-readings. Thus the action of the impurity in the wire is similar to a shunt. R. A.

1013. *Kinetic Theory of Polyatomic Gases.* **F. Richarz.** (Wied. Annalen, 67. 3. pp. 702–706, 1899.)—A double application of the virial equation leads to the conclusion that $\frac{3}{2}pv$ is equal to the kinetic energy of the motion of translation of all the molecules contained in the volume in question. Avogadro's law further implies that every molecule has the same mean kinetic energy of translation. If a polyatomic gas is compared with a monatomic gas like mercury vapour at the same pressure and temperature, it is apparent that the mean kinetic energy of every molecule of it must be equal to that of a mercury atom. But in a monatomic gas the motions of a molecule and of an atom are identical. Hence in a polyatomic gaseous molecule the total mean kinetic energy of a single atom must be equal to the mean kinetic energy of translation of a molecule. This simple deduction of Boltzmann's law is only possible, however, if it is admitted that the kinetic energy of the atom is the measure of temperature.

The author further points out that he had, before Staigmüller's work appeared, deduced Dulong and Petit's law by an application of the virial function, and that his deduction indicated the substances in which a deviation from Dulong and Petit's law could be expected. E. E. F.

1014. *Thermodynamics of Luminescence.* **E. Wiedemann.** (Wied. Annalen, 66. 5. 1180–1181, 1898.)—As Wesendonck (see 1898, Abstract No. 133) appears to have misunderstood the author, Wiedemann repeats his opinion that apparent exceptions to the second law of thermodynamics only occur in cases of luminescence because the luminescent substance is to be regarded as an intermediary between a hotter and a colder body. R. A. L.

1015. *Absolute Temperature.* **K. Schreber.** (Wied. Annalen, 66. 5. pp. 1186–1190, 1898.)—The author defends a point of his theory (see 1898, Abstract No. 1328) against Wiedeburg.

He also claims for his (geometrical) scale of temperatures the name "absolute," rather than for Lord Kelvin's. The scale is defined by—

$$\theta_1 - \theta_2 \qquad \frac{1}{\log 2} \cdot \log \frac{Q_1}{Q_2}$$

where Q_1 Q_2 are the quantities of heat occurring in a reversible cycle between the temperatures θ_1 θ_2. In Kelvin's scale the two standard temperatures, and therefore the value of the degree, are defined by means of the properties of a particular substance, viz., water; Schreber claims to have avoided this. R. A. L.

1016. *Kirchhoff's Law.* **W. Voigt.** (Wied. Annalen, 67. 2. pp. 366–387, 1899.)—The proportionality between thermal emission and absorption has not yet been theoretically explained. The author amplifies the mathematical theory of radiation so as to include the process of emission. He supposes the radiating body to have the shape of a plane-parallel plate excited homogeneously in parallel layers, and emitting plane waves in a direction normal to its surface. He altogether fails to derive Kirchhoff's law from theoretical considerations dealing only with regular trains of waves, and points out that in practice it is only irregular motions that are dealt with. He therefore modifies his theoretical assumptions by supposing that the plane-parallel plate is divided into a very large number of thin and equal layers which are excited in an incoherent manner. The approximation to Kirchhoff's law then becomes very close on introducing a simple relation connecting the parameters of the optical excitations with certain optical constants of the medium. The conceptions arrived at may be applied to the consideration of an isotropic body placed in a magnetic field, with the result that the excitations are independent of the field intensity, and that the Zeeman effects are solely due to a change in the vectors of oscillation. E. E. F.

1017. *Emissivity of Platinum.* **J. E. Petavel.** (Phil. Trans. 191. pp. 501–524, 1898.)—The results of this research have already been noted (see 1898, Abstract No. 1326); the apparatus used is now described. Radiation was obtained by a thick platinum wire, since thin ones give irregular results; the current through it and the E.M.F. near its ends were measured, to determine simultaneously the temperature and power spent. Callendar's formula for the temperature extrapolated up to 1500° was found to agree with Violle's measurement of the melting-point of palladium. The hot wire was placed inside a glass cylinder in which the air pressure could be varied, or which could be filled with steam, CO_2, &c. To determine this radiation, a bolometer was constructed by welding a thin Pt plate on to a thick Ag one, rolling out, and dissolving off the silver; in this way a thickness of 0·00011 cm. was obtained. One face was platinum blacked, the other was backed by a mirror. The instrument was very sensitive, but of somewhat inconstant zero: greater constancy was obtained by evacuating the box containing it, and admitting the radiation through a quartz plate. (The author does not say in which experiments the quartz plate was used, nor whether the use of it sensibly affects the apparent law of radiation obtained.) A candle at 1 m. produced 360 scale divisions deflection. The results on the law of radiation agree fairly with those of Bottomley, Schleiermacher, and Paschen, and confirm Weber's formula. R. A. L.

ELECTRICITY.

1018. *Magnetic Force in Solenoids.* **C. C. Farr.** (Roy. Soc. Proc. 64. pp. 192–203, 1898.)—"Expressions are arrived at, in terms of zonal harmonics and their first derivatives, by which the values of the two components of the magnetic force may be calculated for any point in the interior of a coil."

EDITOR.

1019. *Contact Force.* **J. Brown.** (Roy. Soc. Proc. 64. pp. 369–374, 1899.)—A small copper-zinc condenser was placed in a glass tube together with metallic potassium. The tube was filled with nitrogen at a reduced pressure of about 5 mm. Three sets of measurements of the contact E.M.F. were taken, lasting six months, one and a half years, and seven and a half years respectively. The first set showed a reduction from 0·56 volt to 0·33 volt in 181 days, but this was not confirmed by the other two experiments. Consequently the results do not support a chemical theory of contact force. W. R. C.

1020. *Contact Electrification.* **A. Coehn.** (Wied. Annalen, 66. 5. pp. 1191–1193, 1898.)—The author in a former paper (see 1898, Abstract No. 505) propounded the law that bodies of high dielectric capacity assume a positive charge in contact with insulators of a lower dielectric capacity. Heydweiller tested the applicability of this law to the contact of metals and liquids (see 1899, Abstract No. 273), and concluded that it did not apply, or at least that in this case other properties than the dielectric constant played an important part. In the present note the author emphasises the fact that the law is not applicable to the contact of metals and liquids, owing to the disturbing influences of solution, oxidation, and evolution of gas at the metals. By taking special precautions to avoid these as much as possible, he has, however, found that pure metals are positive with respect to water. Further particulars are promised in a future paper. J. B. H.

1021. *Electric Discharge.* **J. Precht.** (Wied. Annalen, 66. 5. pp. 1014–1018, 1898.)—The author has repeated Faraday's experiments on discharge in air, between pointed and plate electrodes, using the alternative path method, just as Faraday did, with the point electrode positive in the one spark-gap and negative in the other. As generators he used any one of the following: A 20-plate Töpler machine; a Voss machine with 2 plates; a Holtz machine; a small Wimshurst machine, and an

induction coil. With these different generators some remarkable differences in the discharges were noted. With the large machine the discharge always took place between the positive point and negative plate. With the smaller machines the discharge is almost entirely between the negative point and positive plate, and with the induction coil the reverse. Measurements of the differences of potential between the electrodes in each case confirm the results.

The conclusion is that the differences can in no way be attributed to differences in positive and negative electricity, but must be attributed to the output of the generator and the magnitude and rate of variation of the potential at the electrodes.

J. B. H.

1022. *Discharge Streams.* **J. E. Moore.** (Amer. Journ. Sci. 6. pp. 21–40, 1898.)—The author treats the electric discharge in a vacuum tube from the point of view of the kinetic theory of matter. He regards the study of the elementary mechanical transactions in electrical discharge as not merely a study of some interesting light phenomena, but as a study of the elementary actions in electrical conduction, not only in gases, but in liquid and solid conductors as well. A close analogy may be traced between the distribution of the lines of flow of heat from a hot body, and the lines of motion taken by discharge stream. An experiment is described which brings this out in a practical manner. The cups of a Crookes radiometer when heated rotate with the concave side forward. They do the same when charged to a high potential. When the bulb is thoroughly exhausted by means of a Sprengel pump, the movable system is put in connection with one terminal of the two-part commutator for rectifying the alternating potential-difference of the secondary of the induction coil. The cups are seen to rotate, concave side forward. On disconnecting the electrical source, and grasping the bulb in the hands, the cups immediately begin to rotate in the opposite direction, and continue to rotate for a short time before coming to rest. The electrification of the walls is very troublesome, but when they are carefully discharged after each operation, the above direction of rotation, upon connecting the movable system with a source of high potential, has been observed, whether the potential of the source be positive or negative in sign.

The author investigates more particularly the return stream which replaces the matter projected from the kathode.

The return stream from the walls of the tube (travelling in straight lines) must leave the walls at a greater distance from the kathode, in order to reach the central portion of the cylindrical surface, by coming over the sides, than by entering the kathode from the ends. The electrification of the walls of the tube falling off very rapidly from the kathode, the velocity of those parts

of the return stream which spring from points on the walls of the tube near the kathode must be very different from the velocity of those parts coming from points remote from the kathode. The cross-section of the discharge stream from a cylindrical kathode ought, then, to be found to diminish more rapidly (with decreasing molecular density), parallel to the axis of the cylinder, than along the arc of the curved surface. E. E. F.

1023. *Carbon Coherer.* **T. Tommasina.** (Comptes Rendus, 128. pp. 666–667, 1899.)—When brass filings are suspended in water and a feeble current is sent through, the filings form chains, which break up subsequently, not into individual particles, but into short rods. The author attempted to find a substance which would under similar circumstances break up into particles. He succeeded in forming carbon chains 12 to 15 mm. long, and produced a carbon coherer which had a sensitiveness as great as that of the best metallic coherers. They have the advantage of losing their conductivity with the least shock, and, under favourable conditions, the interruption of the current through the coherer suffices to restore the original resistance. Another efficient type of carbon coherer may be made by introducing two cylindrical arc carbons into a glass tube, in which they are held by rubber stoppers in such a position that their ends are lightly in contact. Such a coherer is extremely sensitive, and does not easily get out of order. The author employed this coherer to test whether any extra-currents were induced in the human body by electric oscillations. On holding the terminals between his thumbs and forefingers, he found that the coherer acquired a high conductivity by the impact of electric waves. E. E. F.

1024. *Electro-Thermal Relations.* **E. Riecke.** (Wied. Annalen, 66. 5. pp. 1199–1200, 1898.)—The author in this note mentions that after his work on this subject (see 1899, Abstract No. 299) was in print he received from Van Everdingen a memoir on the galvanometric and thermomagnetic phenomena in bismuth which showed the assumption made of the equal displacement velocities of positive and negative electricity to be incorrect. The author also points out two other oversights in his work above mentioned. S. H. B.

1025. *Thévenin's Theorem.* **J. B. Pomey.** (Écl. Électr. 18. pp. 121–123, 1899.)—This paper discusses the application of Thévenin's Theorem to proving Mance's method of measuring the internal resistance of a battery, and obtaining the best conditions for sensibility, but does not well admit of abstracting. E. C. R.

1026. *Effect of Heat and Moisture on Dielectrics.* **E. Letheule.** (Écl. Électr. 17. pp. 439–442, 1898.)—A section of the apparatus used by Chester and Crellin of the University of Illinois is given, and the curves they obtained summarised and reduced to ohms per cubic centimetre. M. O'G.

1027. *Dielectric Polarisation and Hysteresis.* **W. Schaufelberger.** (Wied. Annalen, 67. 2. pp. 307–324, 1899.)—Ellipsoids of ebonite or paraffin are suspended bifilarly between the vertical plates of a Kohlrausch condenser. All the experiments show a considerably increased damping of the oscillations on charging the condenser. This means that a certain expenditure of energy is necessary in order to keep the direction of polarisation parallel to the electric lines of force. This necessitates a departure from Maxwell's fundamental formula connecting displacement with electric force. The experiments are rendered difficult by the great disturbing effect of moisture. In paraffin, the consumption of energy is proportional to the square of the force. This accords with previous results, except those of Arnò, who found an index of about 1·8 instead of 2. Ebonite is a very imperfect dielectric in comparison with paraffin, and no well-defined results have been obtained for it. E. E. F.

1028. *Dielectric Constants and Density.* **D. Negreano.** (Comptes Rendus, 128. pp. 814–815, 1899.)—The author draws attention to the fact that the formula $\frac{k-1}{(k+2)}\frac{}{d}$ = constant (where k is the dielectric constant and d the density), which is known by the name of the Mossotti-Clausius formula, is not due to these investigators, but was established theoretically by Lorentz in 1880, and experimentally by himself in 1887. A. H.

1029. *Measuring Small Capacities.* **J. J. Borgman** and **A. A. Pétrowsky.** (Comptes Rendus, 128. pp. 420–422, 1899.)—One terminal of a Ruhmkorff coil is earthed or remains isolated, while the other is attached to a movable terminal which may be slid along a groove cut in a block of paraffin and filled with water. At the ends of the groove are platinum electrodes, which are connected to a spectrum-analysis Geissler tube. On starting the coil, the tube glows without showing any polarity. A displacement of the movable terminal along the groove changes the intensity of the glow, and for a certain position of this terminal, a dark space, termed by the authors a *node*, appears in the capillary portion of the tube. The node may be brought

into the middle of the tube by suitably adjusting the position of the movable electrode. This position depends on the capacities of the conductors which connect the electrodes of the tube to the ends of the groove, and the phenomenon may be utilised for the comparison of very small capacities, by connecting the unknown capacity to one of the conductors, and then attaching a known variable capacity to the other, and adjusting it until the node is once more brought back to the middle of the capillary portion of the Geissler tube. Another method is to displace the movable terminal along the groove until the same result is obtained; the displacement is, within certain limits, proportional to the capacity. The author states that by this means capacities as small as a fraction of an electrostatic c.g.s. unit may be measured.

A. H.

1030. *Test to Faults.* **A. Jordan** and **W. Schonau.** (Elect. Rev. 44. p. 233, 1899.)—Referring to Elect. Rev. October 12, 1894, it is possible to modify the Earth Overlap Test to localise a fault without its being necessary for the two terminal stations to communicate with each other after each reading. Diagrams are given showing how to use Mance's method in this conjunction where the fault is liable to polarise. M. O'G.

1031. *Experiments with Wehnelt Interrupter.* **H. Pellat.** (Comptes Rendus, 128. pp. 732–734 and 815–817, 1899.)—When the interrupter is connected direct across a 110-volt circuit, the current is found to be 4 to 5 amperes. On disconnecting and joining it up in series with the primary of an induction coil (25 cm. spark), the current is found to exceed 25 amperes, a flame stretching across the secondary spark-gap. Thus the mean value of the current is increased by the introduction of an impedance into the circuit of the interrupter. If now while the coil is at work its primary be suddenly short-circuited by a stout piece of copper wire, the secondary sparks cease immediately, but the primary current remains at its high value during a few seconds, after which it suddenly drops to 4 or 5 amperes. If while the latter current is passing, the short-circuit be removed, so that the primary of the coil is once more thrown into the circuit of the interrupter, the current remains feeble, and there is no sparking across the secondary terminals, even when they are gradually brought nearer together until almost in contact. This condition will persist for any length of time. It never arises spontaneously, for if the circuit be momentarily broken and re-established, a flame immediately shoots across the secondary spark-gap, and the primary current rises to over 25 amperes. The author attempts to develop a mathematical theory of these phenomena, and arrives at the conclusion that the inductance of the circuit and the reaction

of the secondary coil have only an indirect effect in imparting greater stability to one or other of the two possible conditions under which the interrupter may receive current from the mains.
A. H.

1032. *Electrical Measuring Instruments.* **C. T. Child.** (Amer. Electn. 10. pp. 510–512, 1898.)—Instructions are given for making a simple voltmeter, ammeter, wattmeter, and energy integrating meter. W. R. C.

1033. *Tesla's Interrupter.* (Elect. Rev. N.Y. 33. p. 247, 1898.)—The patent specification is given. The interruptions are obtained by a stream of mercury impinging upon a rotating disc having projecting teeth. The interruptions take place in a gas under pressure, thus permitting a much higher frequency than would otherwise be possible. W. R. C.

1034. *Carbon-Consuming Batteries.* **A. J. Rogers.** (Elect. Rev. N.Y. 34. p. 56, 1899. Paper read before the North-Western Electrical Association, Milwaukee.)—A short account of recently suggested carbon-consuming cells. W. R. C.

1035. *Harmonic Analyser for Alternate Currents.* **T. des Coudres.** (Berlin Phys. Gesell. Verh. 17. pp. 129–132, 1898.) —The author proposes to construct an analyser on the following principle: The current $F(x)$ is sent through the fixed coil of an electrodynamometer. The movable coil is connected to the terminals of a sine inductor, whose period is a submultiple T/n of the main period. The couple between the two coils is proportional to the product of the two currents, *i e.*—

$$n \sin (nx)\, F(x)$$

if the time is chosen so that the sine inductor current just changes sign at time O. The mean couple to be compensated by the torsion head is—

$$a_n = k \,.\, n \frac{1}{\pi} \int_0^{2\pi} F(x) \sin (nx)\, dx \,.$$

where k is the constant of the apparatus. But that is the coefficient A_n of the Fourier series for $F(x)$, down to the factor kn:—

$$A_n = \frac{1}{\pi} \int_0^{2\pi} F(x) \sin (nx)\, dx$$

$$a_n = kn\, A_n \,.$$

On turning the coil of the Kohlrausch sine inductor through 90°, so that its current for $x = \pi/2$ is zero, the dynamometer reading becomes—

$$\beta_n = k \,.\, n \,.\, \frac{1}{\pi}\int_0^{2\pi} F(x) \cos(nx)\, dx$$

$$\beta_n = kn\, B_n \,.$$

Hence it is only necessary to let the sine inductor run successively to frequencies, 1/T, 2/T, 3/T, and to read the successive dynamometer deflections α and β, to obtain successive terms in the Fourier series. E. E. F.

1036. *Hysteresis Errors in Measuring Instruments.* **W. M. Stine.** (Elect. World, 33. pp. 200–202, 1899.)—The author first describes a modification of the Wheatstone-Kelvin rheostat which was used in making the experiments, enabling a potential difference to be varied with perfect continuity. The experiments were made on several voltmeters of different commercial patterns all containing a soft iron movable armature either singly or in combination with a fixed piece of soft iron for opening out certain parts of the scale.

The voltmeters were put in parallel with a Weston voltmeter, an instrument possessing no hysteretic error, the voltage being uniformly increased from zero up to the maximum reading of the instrument, and then decreased back to zero. In all cases a marked loop is found between the ascending and descending readings. In some of the cases the maximum voltage was kept on for ten minutes before the descending readings were taken, this with some of the instruments shows evidence of a magnetic lag, the deflection creeping up to a higher value when the impressed voltage remains at a fixed value. Readings were also taken with a key in the voltmeter circuit which was broken between every reading; this method gives much smaller hysteretic errors, the ascending and descending curves being nearly coincident. The paper is illustrated with curves giving results obtained.

The conclusions arrived at by the author are that this type of instrument is eminently unsuited for the laboratory. No matter how carefully the instrument is calibrated the subsequent readings cannot be relied on, for the error is not constant, but varies with conditions which cannot be accurately ascertained. With alternating currents they are more reliable, yet hysteresis is not wholly eliminated, and they cannot be considered accurate. E. C. R.

1037. *Determination of H by Unifilar and Bifilar Magnetometers.* **H. Wild.** (St. Petersburg Acad. Sci. Bull. 8. pp. 239–252, 1898.)—In careful measurements carried out by both

methods the author found a constant difference between the results of the two methods, which was about ten times the probable error of an observation, the higher value being always obtained with the bifilar instrument. With a unifilar magnetometer, the horizontal intensity is (using the method of sines and neglecting corrections) given by

$$H_u = \frac{\pi}{T}\sqrt{\frac{2I}{d^3 \sin\theta}}$$

while the formula for the bifilar instrument is

$$H_b = \sqrt{C.\, mg}$$

where C is a constant, m the mass of the suspended body, and g the acceleration due to gravity.

The corrections to be applied in the two cases are essentially different. In finding T, the resistance due to viscosity of the air must be taken into account, and the corresponding correction will render H_u greater. There is a further correction due to the inductive effect of the earth's field and the mutual inductive effect of the magnets. This correction is calculated by the author. The bifilar magnetometer is, on the other hand, quite free from this error. But it is subject to a correction for the buoyancy due to the air displaced by the magnet; and this will obviously render H_b less than that calculated by the above formula. The author finds that on applying all these corrections the discrepancy between the values obtained with the two instruments is reduced to a much smaller amount. A. H.

1038. *Annual Magnetic Variation.* **G. Schwalbe.** (Berlin Phys. Gesell. Verh. 17. pp. 138–140, 1898.)—The daily magnetic period is due to currents circulating above the surface of the earth. The laws of such periods may be easily determined by plotting the successive values and directions of the horizontal magnetic force in a vector diagram. Such vector diagrams should be oriented in the astronomical, and not in the magnetic meridian. The periodic variations are then indicated by closed curves. The yearly period is the residue of the annual variation remaining after eliminating the divisional and the secular variations. If X is the component of H directed towards the north, Y that directed towards the east, and δ the westerly declination, we have

$$X = H\cos\delta, \qquad -Y = H\sin\delta$$

and by differentiation

$$dX = \cos\delta\, dH - H\sin\delta\, d\delta$$
$$dY = -\sin\delta\, dH - H\cos\delta\, d\delta,$$

so that the variations of X and Y may be found from those of H and δ. On calculating the annual period for several points on

the earth's surface, it is found that in the northern hemisphere the westerly declination and the horizontal force, as well as X and Y, have a maximum in summer and a minimum in winter, while the reverse applies to the vertical force. In the southern hemisphere the reverse holds good. This permits of a conclusion with regard to the seat of the force producing the annual variation. The simultaneous increase of the westerly declination and H from winter to summer means that the north end of the magnetic needle is in summer influenced by a south pole or its equivalent, *i.e.*, an easterly current below the earth's surface, or a westerly current above it. The fact that at the same time the vertical force is weakened and the needle-point is urged upwards, shows that the current influencing it circulates in the upper atmosphere. Similar reasoning applied to the southern hemisphere leads to the same conclusion, so that both periodic disturbances are due to these currents. E. E. F.

1039. *Magnetic Inclination deduced by Magnetisation of Clay.* **G. Folgheraiter.** (Roma R. Accad. Lincei Atti, 8. pp. 121–129, and 176–183, 1899.)—For description of method see Abstract No. 839 (1899).

The civic museum of Arezzo possesses an important collection of vases made in *the first half of the century* B.C., many being authoritatively marked with the maker's name. It also contains moulds employed in the making of the vases. The inclination calculated from observations on six vases is 61° 23′; whilst the value calculated from eleven moulds is 61° 3′. The north pole dipped as at present.

The national museum of Naples contains a collection of vases excavated from Pompeii. As it is probable that cheap domestic articles were made in the neighbourhood where they were used, the author examines these rather than articles of luxury. From twenty-four cups and jars the value of the inclination is 66° 50′. From ten vases for preserving food the value is 66° 20′, differing but little from the preceding.

Various museums of Italy contain collections of Attic vases, which are generally divided into two groups: (1) those with red figures on a black ground, (2) those with black figures on a red ground. The results from these vases are not very consistent, perhaps due to some of the vases not belonging to the period imagined by the archæologists. On the whole they perhaps indicate that in certain parts of Greece the inclination was almost zero about 600 B.C., and not far from 20° about 400 B.C.

The author suggests that rebaking the vases might enable the *magnitude* of the earth's field to be determined at the time of their manufacture. A. Gs.

1040. *Boiling-Points in the Magnetic Field.* **H. du Bois.** (Berlin Phys. Gesell. Verh. 17. pp. 148–151, 1898.)—It is shown theoretically that a paramagnetic liquid undergoes in the magnetic field an increase in its boiling-point, and a diamagnetic body a diminution, the change varying with the field and the susceptibility, and inversely as the density and the heat of vaporisation. If the body is a solid capable of sublimation, like anhydrous chloride of iron, the temperature of sublimation is similarly raised. This means that the vapour pressure curves of both the solid and the liquid phases are displaced in the magnetic field. Hence also the fusing-point, determined as it is by their intersections, must be displaced. The change in the boiling point is calculated for a few liquids, exposed to a magnetic field of 50,000 c.g.s. units. For liquid oxygen it would be about $+0{\cdot}01°$, for water -15 millionths, and for ethyl ether -100 millionths of a degree. The reasoning given cannot be directly applied to solutions, on account of possible changes of concentration. But for a concentrated aqueous solution of ferric chloride it must be of the order of one-thousandth of a degree, a quantity whose measurement is not hopelessly impossible. E. E. F.

1041. *Magnetism and Thermal Conductivity of Iron.* **D. Korda.** (Comptes Rendus, 128. pp. 418–420, 1899.)—The thermal conductivity of soft iron is decreased along the lines of force, and remains unaffected in directions normal to the lines. If a disc of soft iron, 320 mm. in diameter and 0·35 mm. thick, provided with a concentric circular vessel 90 mm. in diameter, be coated with a thin layer of paraffin wax, and hot water be introduced into the vessel, the wax melts along concentric circles. But if the disc be placed between the poles of a magnet, the plane of the disc being parallel to the field, the wax melts along an ellipse. The theory of this phenomenon is given, and it is shown that the effect is proportional to H^2. A. H.

1042. *Theory of Magnetism.* **H. du Bois.** (Elekt. Runds. 16. pp. 80–82, 1898.)—A brief historical sketch dealing with the development of modern magnetic theories, with special reference to the important contributions due to the late Dr. Hopkinson.
A. H.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

1043. *Colloidal Glass.* **C. Barus.** (Amer. Journ. Sci. 6. p. 270, 1898.)—The author has succeeded in impregnating glass with water to such an extent that it becomes fusible below 200° C. The clear water-glass so obtained, if heated in a gas-burner, swells up with loss of water, and is reduced to a white porous mass. On the basis of his experiments the author announces that glass as a *colloid* is miscible with water in all proportions. Such solutions if sufficiently concentrated *coagulate* at ordinary temperatures, the congealed aqueous glass resembling ordinary glass in general appearance, and melting frequently under 200° C. F. G. D.

1044. *Thermodynamic Relations of Hydrated Glass.* **C. Barus.** (Amer. Journ. Sci. 7. pp. 1–3, 1899.)—The author studies the action of hot water on glass (200° C.). There are two stages. In the first the glass becomes opaque, and there is relatively great contraction of volume and increase of compressibility. In the second the product (water-glass) becomes more and more clear, the volume-contraction falls off asymptotically to zero, and the compressibility after reaching a maximum diminishes with great rapidity. On cooling, the product is clear, and as hard and brittle as ordinary glass. Held in a candle-flame, a small piece soon fuses with loss of water to a milk-white pumice. The author interprets the phenomena observed in the light of Gibbs' Phase Law, assuming the existence of two phases of the water-glass. F. G. D.

1045. *Aqueous Fusion of Glass.* **C. Barus.** (Phil. Mag. 47. pp. 104–109, 1899.)—The results of experiments on the action of water at 185° C. on glass are given. The water was kept liquid by pressure. These results are stated in the subjoined table. The water was contained in sealed capillary glass tubes, and while it increased in compressibility it steadily diminished in bulk; the thread was contained within the walls of the tube between two terminal threads of mercury, and the decrease of the length of the thread of water which occurred indicated contraction of volume of the system of glass and water in contact. In the table, θ denotes the temperature of the capillary thread; t, the time of the observation, counting from the beginning of ebullition in the vapour-bath used to keep the temperature constant; v, the total increment of volume due to the thermal expansion; V, the total volume, so that v/V is the mean expansion per unit volume at 185°; β, the mean compressibility within 300 atmospheres.

Table showing Thermal Expansion and Compressibility of Silicated Water at 185° and 20 to 300 atmos. Diameter of tube 0·045 cm. Length of column of water at 24°, 14 cm.

θ	$v/V \cdot 10^3$.	$\beta \cdot 10^6$.	t
24 ° C.	±0	44	
185	+103	77	18 min.
185	86	97	25
185	75	112	30
185	60	125	35
185	+44	141	40
185	+27	163	45
185	+05	184	50
185	−15	221	55
185	−29		60

At the conclusion of the experiment the thread seemed to be solid at high pressure (300 atmos.), though not apparently so at low pressure. Examining the values of v/V given in the table, it appears that whereas the original volume increment per unit of volume is greater than 0·103 for the rise of temperature from 24° to 185° at 20 atmos., this increment has nearly vanished after 50 minutes of reaction. The thread at 185° is now only as long as it was at 24°. After 60 minutes of reaction it is even markedly shorter at 185° than at 24°, pressure remaining constant throughout. At the same time the compressibility, β, of the silicated water at 185° is found to increase regularly from 0·000077 near the beginning of the experiment, to over 0·000221, or more than three times its initial value on the same isothermal (185°). This result is remarkable and unexpected, since without exception the effect of solution is a decrease of the compressibility of the solvent, in proportion as more substance is dissolved. Silicated water in the present experiment shows the reverse. Correlative experiments were made with saturated solutions of zinc sulphate in water, and naphthalene in alcohol. In both cases markedly increased compressibilities were possible in a turbid column, due to the precipitation of part of the dissolved salt, isothermally, by pressure. During compression a part of the dissolved body is changed from the liquid to the solid state by pressure, and hence the apparent increase of compressibility. The reaction of the water on the glass must be along the surface of contact, and the length of the column of water will decrease faster for small values of the capillary radius. In the experiment described the volume of water absorbed per sq. cm. of surface of contact corresponds to about 180 kg. per sq. metre per year at 185°. These experiments have an important bearing on the behaviour of water in finely porous rocks. The pressure and temperatures in the experiments made would be more than reached by a column of water penetrating a few miles below the earth's surface. The

action of hot water on rock within the earth seems to constitute a furnace whose efficiency increases in a marked degree with the depth of the seat of reaction below sea-level. J. J. S.

1046. *Gases Occluded by Moist Glass.* **F. Mehlhorn.** (Berlin Phys. Gesell. Verh. 17. pp. 123–128, 1898.)—The author investigates the absorption of atmospheric air by the thin coating of moisture which, according to Bunsen's researches, adheres to glass until it is brought to a temperature of 500°. He finds that 80 or even 90 per cent. of the gas thus absorbed consists of carbonic acid. This explains to some extent the persistent occurrence of the spectrum bands of CO in the sparking spectra, since CO is generated by sparking CO_2. E. E. F.

1047. *Process of Crystallisation.* **A. Heydweiller.** (Wied. Annalen, 66. 5. pp. 1194–1195, 1898.)—The author replies to Tammann's criticism (see 1899, Abstract No. 326) of his discovery of a continuous transition between solid and liquid menthol, apparent continuity being ascribed to impurities in the menthol used. The author maintains that the phenomena observed are the same in specimens of menthol purified by repeated freezing. In the experimental arrangement used, the menthol must in fact purify itself. The author also fails to conceive how the solution of foreign substances in the liquid menthol could lead to the disappearance of the meniscus separating the solid and liquid phases. E. E. F.

1048. *Reaction Velocity in Aqueous Alcohol.* **W. Kistiakowsky.** (Zeitschr. Phys. Chem. 27. pp. 250–266, 1898.)—The equation of the progress of reaction is confirmed, and the same constants found by decomposition as by formation of etherial salts in presence of HCl: the autocatalysis without HCl is also investigated. The former are first retarded somewhat and then considerably accelerated by increasing the strength of alcohol; the latter are always retarded. The chloracetic acids form a transition in behaviour from organic to inorganic acids. Acetic acid gives smaller constants than formic, chloracetic than acetic, as the difference in ionisation predicts. B. B. T.

1049. *Electrosynthesis.* **W. G. Mixter.** (Amer. Journ. Sci. 6. pp. 217–224, 1898.)—Gases under various conditions of pressure and mixture are enclosed in endiometers connected in parallel. The heat resulting from the combination effected by

the feeble glow discharge does not cause further combination, as is shown by the fact that when the discharge is concentrated in a small space there is no increase in the proportion of hydrogen and oxygen combined. The higher the pressure the more rapid is the combination, but no simple relation can be traced between them.

A mixture of 23·6 cc. of oxygen and 28·8 cc. of ammonia contracted by 23·9 cc., five-sixths of the nitrogen supplied being thus absorbed, while the remainder entered into a non-gaseous compound. This was ammonium nitrite, which formed a white coating on the sides of the endiometer, and which reacted for nitrous acid with the usual tests. The products obtained with a mixture of cyanogen and oxygen are very complicated, but it is certain that cyanogen is oxidised more rapidly than hydrogen. The following table gives a summary of the probable changes, one vol. of hydrogen and oyygen being supposed to contain 100 molecules :—

Gases used.	Molecules reacting.	Molecules oxidised.		Molecules of Oxygen consumed.
Hydrogen and oxygen ...	100	H_2	67	33
Ammonia „ ...	168	NH_3	88	72
„ „ ...	179	„	89	77
Methylamine „ ...		NH_2CH_3	46 to 70	
Dimethylamine „ ...		$NH(CH_3)_2$	57 to 70	
Trimethylamine „ ...	265	$N(CH_3)_3$	42	213
Hydrogen and nitrous oxide	112	H_2	56	
„ nitric „	Little if any hydrogen oxidised.			
Carbonic oxide and nitric oxide.	Some carbonic oxide oxidised.			

E. E. F.

1050. *Chemical Actions of Electric Brush Discharge.* **Berthelot.** (Annal. Chim. Phys. 16. pp. 5–80, 1899.)—The author has made a long series of further experiments concerning the action of the *effluve électrique*, more especially with regard to the fixation of nitrogen by organic compounds. The bodies dealt with contain only the four elements oxygen, nitrogen, hydrogen, and carbon, so as to limit the field of investigation. The author maintains that the results obtained open up a very wide and fruitful field of research, equal in importance to pyro-chemistry. The bodies exposed to the action are placed either singly or in a mixed state into a narrow space between armatures, where they act as dielectrics, and are subjected to a noiseless and invisible discharge from a rapidly interrupted induction coil of 12 mm. spark-length. The duration of each experiment is 24 hours, but intermediate products are also examined. The usual form of apparatus employed consists of two concentric glass tubes with a cylindrical space 1 mm. thick between them. Various pressures and various

temperatures are employed. Most of the experiments quoted deal with gaseous bodies; but there are also a few on liquids and solids. Essence of terebenthene is slightly polymerised in 24 hours. So is olive oil. Alcohol gives off some hydrogen and ethane, and about 1 per cent. is converted into aldehyde. The action observed in general consists of two distinct parts: a decomposition giving rise to the separation of hydrogen and the simplest binary compounds, and a condensation or polymerisation leading to the formation of complex substances of a high order. The author points out the analogy to what happens to food taken into the animal body.

Carbonic oxide and anhydride, acted upon in the presence of an excess of hydrogen, produce carbo-hydrates, the general formula being

$$\left.\begin{matrix} n\,(CO+H_2) \\ n\,(CO_2+2H_2) \end{matrix}\right\} = C_nH_{2n}O_n - mH_2O$$

With deficiency of hydrogen, more highly oxidised compounds are obtained. The presence of nitrogen leads to the formation of richly nitrogenised compounds of the uric or xanthinic type. When water is formed, ammonium nitrite is formed as well.

The carbides of the acetylene series are changed into condensed polymers, without notable loss of hydrogen. The ethylene series is also polymerised, loses hydrogen, and approaches the camphene series. The formenes are converted into ethylenes. All the carbides fix nitrogen and form alkaline compounds of the polyamine type, probably cyclical. Some of the transformations are only suggested by the empirical formulæ. It is just as likely that new and hitherto unknown compounds are formed.

All the alcohols studied absorb nitrogen when present in the gaseous state, forming amidines and related bodies. This fixation is, in the case of the fatty alcohols, accompanied by a loss of hydrogen. The aldehydes and the organic acids also fix nitrogen under the influence of the silent discharge. In the case of the acids, there is practically no loss of hydrogen, the presence of the oxygen tending to maintain it fixed in the molecule, usually as water. One molecule of acid fixes about an atom and a half of nitrogen, at least in acetic and propionic acids. E. E. F.

1051. *Equation for Reversible Reactions.* **J. Waddell.** (Journ. Phys. Chem. 3. pp. 41–45, 1899.) Walker and Hambly's simplified equation for a monomolecular reversible reaction (Journ. Chem. Soc. 67. p. 753, 1895) is shown to be mathematically valid, but not that for a bimolecular reaction. Instead of $dx/dt = k\,(x-\xi)^2$ the author finds $dx/dt = k_1\,(1-\alpha)\,(x-\xi_1)\,(x-\xi_2)$ where $\alpha = k_2/k_1$ and ξ_1 and ξ_2 are the roots of $k_2/k_1 = (A-\xi)^2/\xi^2$ namely, $\xi = A/(1 \pm \sqrt{\alpha})$. Here $\xi_2 (= A/\{1+\sqrt{\alpha}\})$ is the actual

value of x at the equilibrium point, ξ_1 is the impossible value for the same. Integration gives a constant, the values of which are calculated; the agreement is worse than the old equation showed. B. B. T.

1052. *Theory of Residual Current.* **E. Salomon.** (Zeitschr. Phys. Chem. 25. pp. 365–371, 1898.)—The author states that his theory of the residual current with polarised electrodes (Zeitschr. Phys. Chem. 24. p. 55, 1897) was false in principle, and gives the correct theory of Jahn; the calculated values are, however, about fifteen times smaller than the observed, while the old formula gives empirically a rough coincidence. B. B. T.

1053. *Boiling-Points of Mixed Solutions.* **T. W. Richards** and **W. L. Harrington.** (Zeitschr. Phys. Chem. 27. pp. 421–425, 1898.)—A liquid containing several salts in solution boils at a lower temperature than that calculated by adding together the depressions of the boiling-point due to each salt by itself; this behaviour is due, at least in part, to the formation of double salts which lower the osmotic pressure. It may, however, be partly due to the dissociation of one salt being affected by the presence of another. To investigate this point the authors propose to choose such mixtures as show a tolerable alteration of B.P. and are little likely to form double salts. Such are cadmium oxalate in dilute hydrochloric acid, in which the maximum B.P. occurs with a 25 per cent. strength of the acid. With these, the mean of four experiments gave 0·101° as the lowering of B.P. by 1 gram-molecule of CdC_2O_4 in 10 litres of water containing a slight excess of HCl, while the theoretical rise of B.P. due to addition of 1 gm.-mol. to the same mass of water is 0·052°; the mixture thus seeming to result in a diminution of the number of gm.-mols. by 2, while the theoretical reaction gives a reduction of 3. Molecular combinations therefore appear to accompany the reaction. The replacement of the oxalate by the citrate alters the lowering of B.P. to 0·434°, so that 8 active molecules seem to be removed, theory giving 7. R. E. B.

1054. *Boiling-Points of Mixed Solutions.* **C. McC. Gordon, L. J. Henderson,** and **W. L. Harrington.** (Zeitschr. Phys. Chem. 27. pp. 425–428, 1898.)—The authors investigated the effect of adding $CdSO_4$ to solutions of NaCl, in which the action is much more complicated than that in the previous Abstract, from the greater abundance of double salts that may be formed, and their results show that theoretical calculation is useless without exact knowledge of these ever-varying reactions. They found the lowering of B.P. with continuous addition of $CdSO_4$ to

increase to a maximum and then to fall off, the hitherto unknown case of the addition of a solid raising the vapour pressure of a solution being thus exhibited. R. E. B.

1055. *Freezing- and Boiling-Points.* **A. Battelli** and **A. Stefanini.** (N. Cimento, 9. pp. 5–66, 1899.)—As a result of a very elaborate and painstaking research, the authors arrive at the conclusion that the molecular depression of the freezing-point remains practically constant as the dilution increases, and that for very dilute solutions it has a value not differing much from 1·87. This means that Raoult's straight line is confirmed, and the curve found by the majority of other investigators is disproved. A few experiments were also made to determine the boiling-point of tartar-emetic solution, and it was found that the molecular weight thus deduced did not sensibly alter with the dilution. E. E. F.

1056. *Solubility, Ionisation, and Heat of Solution.* **H. Goldschmidt.** (**G. v. Maarseveen.**) (Zeitschr. Phys. Chem. 25. pp. 91–99, 1898.)—The solubility and ionisation of $AgC_2H_3O_2$, $AgC_3H_5O_2$, $AgC_4H_7O_2$ (iso), and o-nitrobenzoic acid were determined and the heat of solution calculated by van't Hoff's formula $\frac{d \log S}{d T} = \frac{q}{2 i T^2}$ (S is solubility), and van Laar's formula $\frac{d \log S}{d T} = \frac{q (2 - \alpha)}{4 T^2}$ compared with that directly observed. The last lies, in the case of the highly ionised silver salts, between the two calculated values, while the weakly ionised acid, which obeys Ostwald's law of dilution, agrees with the latter formula, which premises such obedience. B. B. T.

1057. *Ionisation in Stages of Dibasic Organic Acids.* **W. A. Smith.** (Zeitschr. Phys. Chem. 25. pp. 144–177 and 193–264, 1898.)—The author determines the ionisation-constant of the first H atom of 26 dibasic organic acids from the conductivity, and that of the second H atom, in the acid sodium salts of the same and 35 others, by the velocity of sugar inversion at 100° in various concentrations (Trevor, Zeitchr. Phys. Chem. 10. p. 321, 1892); one tribasic acid (citric) is included. The reliability of the method is investigated, and the reduction factor (inversion-constant/conductivity) found to vary from 13 to 16½ with the acid and concentration, the latter influence vanishing when the ionisation is complete. Water alone inverts considerably and irregularly, as also neutral salts, but this action is restrained by the presence of acids. The accelerating influence of salts on acids

seems to be proportional to the ionising tendency of the acid they contain, rather than their actual ionisation. The time correction is better avoided by calculating from the inversion observed after the first time interval. Ostwald's dilution formula holds for the acids, while for the acid salts the concentration of H is constant, as Trevor found and Noyes (Zeitschr. Phys. Chem. 11. p. 495, 1893) proved theoretically. In the homologous series investigated (oxalic, substituted malonic and succinic, phthalic, maleic and fumaric, camphoric, &c.) Ostwald's rule that the first H atom is weaker and the second stronger, the nearer the acid groups are to one another, is confirmed; the second is always found to be weakened by the entrance of substituting groups except hydroxyl; and lastly, in substituted acids (alkylmalonic and succinic acids) the second atom is weaker, the stronger the first (contrary to Noyes' rule). B. B. T.

1058. *Validity of the Calculation of Ionisation from Conductivity.* **H. Jahn.** (Zeitschr. Phys. Chem. 27. pp. 354–356, 1898.)—The author points out that in deducing $\alpha = \frac{\lambda}{\lambda_\infty}$ from $\lambda = \alpha\,(u+v)$ the assumption is made that u and v are independent of the concentration. This is probable for weakly ionised compounds, and hence also Ostwald's dilution formula $\frac{(\lambda/\lambda_\infty)^2}{V(1-\lambda/\lambda_\infty)} = K$. As this does not hold for strong electrolytes, while the validity of the law of mass action requires that $\frac{C^2}{C_1} = k$ (where C and C_1 are the concentrations of ion and undissociated compound, and equal to α/V and $(1-\alpha)/V$), and therefore $\frac{\alpha^2}{V(1-\alpha)} = \text{constant}$, the author concludes that $u+v \neq u_\infty + v_\infty$ and hence $\alpha \neq \lambda/\lambda_\infty$. Measurements like those of Hopfgartner and Hoffmeister give uC direct. The author states preliminarily that he finds uC $\sqrt{V}$ constant "in every electrolyte."

[This is presumably a misprint for C $\sqrt{V}$ = constant: uC $\sqrt{V}$ = constant would imply by analogy vC $\sqrt{V}$ = constant, whence $(u+v)$C $\sqrt{V} = \lambda\sqrt{V}/\sqrt{V} = \lambda/\sqrt{V}$ = constant, which is *not* the case.] B. B. T.

1059. *Conduction in Mixed Electrolytes.* **K. Hopfgartner.** (Zeitschr. Phys. Chem. 25. pp. 115–143, 1898.)—Author extends work of Schrader (Zeitsch. f. Elektrochem. 3. 498) to mixtures of HCl with NaCl and $BaCl_2$ and $CuSO_4$ with $MgSO_4$ in N and N/5 solutions. The amounts of each kation transported in a mixture are determined by analysis: the ratio of these should be, according to Planck's theory (Wied. Ann. 39. 161), pro-

portional to that of the concentrations × the respective mobilities. Assuming the latter equal to their values in dilute solutions, the former are calculated and found to compare (within 3 to 25 per cent.) with those deduced from conductivity measurements of equally concentrated solutions of each salt alone. Hence the ionisations of these salts are not (greatly) changed by mixture.

The transference values of HCl, NaCl, and $BaCl_2$ are also determined for various concentrations from N/10 to 9N/10 and a slight fall found for the first and a decided rise (0·35 0·38 and 0·38–0·42) for the latter two. From these are calculated the total amounts of kation liberated and an agreement found to within 3 or 4 per cent. with the measurements of a silver voltameter: the sulphates differ more (10–20 per cent.). B. B. T.

1060. *Conduction in Mixed Electrolytes.* **H. Hoffmeister.** (Zeitschr. Phys. Chem. 27. pp. 345–353, 1898.)—The author investigates mixtures of $AgNO_3$ with HNO_3 and $NaC_2H_3O_2$ with $C_2H_4O_2$, in the same way as Hopfgartner (see preceding Abstract); the concentration of the Ag and Na ions is calculated and found to agree with that for the same concentration of pure substance when the admixture is not in excess, in which case it is reduced, as theory predicts. B. B. T.

1061. *Fluidity and Electrolytic Conductivity.* **R. Dennhardt.** (Wied. Annalen, 67. 2. pp. 325–344, 1899.)—The attempt to trace a close relation between fluidity and conductivity fails in the more concentrated solutions. Oleic acid and oleates have peculiar properties. The maxima of molecular conductivity in their alcoholic solutions correspond to minima of temperature coefficient. E. E. F

1062. *Electrolytic Formation of Alkali-Amalgams.* **A. Schoeller.** (Zeitschr. Elektrochem. 5. pp. 259–261, 1898.)—The attempt to establish equilibrium between electrolytic polarisation of mercury electrodes in solutions of alkalies (NaOH and $Ba(OH)_2$) and concentration of the amalgam formed, fails in consequence of re-solution causing a residual current. The E.M.F. of amalgams so formed was observed and found to agree with that calculated from the concentration by Nernst's formula. B. B. T.

1063. *Electrolysis of Water.* **D. Tommasi.** (Elect. Rev. 44. pp. 293–295, 1899.)—In order to account for the electrolysis of water on the application of an E.M.F. much lower than that

corresponding to its heat of formation, the author suggests that water at any temperature contains a certain amount of uncombined oxygen and hydrogen, these uncombined molecules exercising, nevertheless, a certain attraction upon each other. This idea is supported by the work of Deville upon the decomposition of water by heat. The electrolytic separation of these uncombined molecules the author terms *pseudo-electrolysis*.

[This suggested dissociation is apparently quite distinct from ionisation.] W. R. C.

1064. *Chemical Properties of Aluminium.* **A. Ditte.** (Comptes Rendus, 128. pp. 195–201, 1899.)—In a former paper (see 1899, Abstract No. 847) the author showed that aluminium is dissolved by a solution of common salt, provided some weak acid is present. In this paper the oxygen abstracted by the solution from the air is shown to materially hasten the action, especially near the surface of the liquid. When no acid is introduced into the solution, the carbonic acid which the liquid abstracts from the air can fulfil its purpose, and hence it is that aluminium is slowly dissolved in salt water exposed to the air. The action in the case of sea water containing, besides common salt, other chlorides and also bromides is considered. J. B. H.

1065. *Progress of Aluminium.* (Engineer, 87. pp. 155–156, 1899.)—This article describes the advance made in the extraction and treatment of aluminium during the last two years, and *inter alia* refers at length to Wallace's paper before the Soc. Chem. Ind. (see 1898, Abstract No. 961). The yield of aluminium by the Héroult process is now 1 lb. per 12 E.H.P. hours, with a pressure of 3 to 5 volts and a bath-temperature of 750°–850° C. Accepting Thomson's figure for the atomic weight of Al (26·77 when H = 1) and the theoretical voltage of the Héroult cell as 2·4 (obtained by deducting 0·65 volt, the electrical equivalent of the heat of formation of carbon monoxide, from 3·05 volts, the theoretical E.M.F. of liquid alumina), the theoretical output of Al per E.H.P. day of 24 hours is 5·487 lb. Taking the mean (4) of Wallace's voltages, the energy efficiency of the process is 36·45 per cent. and the current efficiency is 60·07 per cent. Two or three years ago these numbers were 22·7 and 40·6 per cent. respectively.

The proposal made in 1892 by Chatterton for the application of power obtainable from the Periyar Irrigation Works (in India) to the production of aluminium has not yet been taken up. But, meanwhile, Chatterton, by teaching the methods of working the metal in the Madras College of Engineering, is accustoming the natives of Southern India to the use of aluminium, and so preparing a demand which in time may lead to the establishment locally

of a new electric smelting industry. Hunt (see 1898, Abstract No. 437), has claimed that with aluminium at 29 cents per lb. it can compete with copper for conductivity purposes, and with wire for a given current would show for the same cost a gain of 52 per cent. in weight and of 60 per cent. in strength, with an increase of 26 per cent. in diameter. He reckoned the conductivity at 63 (Cu = 100). Kershaw (see 1899, Abstract No. 164), taking the conductivity at 59, and with certain other data, finds the Al to be $1\frac{1}{8}$ times as costly as Cu. Accepting Lord Kelvin's latest determination of conductivity (60·5 for 99·7 per cent. Al), the true electrical capability of the metal would lie between Hunt's and Kershaw's figures. Russell estimates an increase of 10 to 15 per cent. in cost against aluminium. But the two metals can only come into competition for bare wires, as the comparatively great diameter of Al conductors necessary for a given current capacity militates against the economical use of this metal for insulated wires. Nevertheless aluminium has been used for telephone work, and at Foyers and Pittsburgh and in Germany it has been employed for heavy currents apparently with success. It is also to be used to conduct a 30,000 volt current from the generating station of the Snoqualmie Falls Power Co. to Seattle and Tacoma, 20 miles distant. The principal use for aluminium is in the iron and steel foundry, where it is very commonly added in small quantities to the metal immediately before casting. The next largest field is in the manufacture of cooking utensils. Opinions differ as to the utility of aluminium for shipbuilding. As Ristori has shown, a part of the prejudice against it is traceable to the early use of an alloy of Al with 6 per cent. Cu, which, naturally, was rapidly corroded in salt water. Nevertheless the metal has been unduly corroded, even where not in contact with more electro-negative metals, on the sheathing of the yacht *Defender*; and the cause of this has not yet been explained. The Spanish-American war has demonstrated the value of the metal as a substitute for inflammable wood in warships. The soldering of aluminium is inevitably a trouble, as all the solders of sufficiently low fusing-point are electro-negative to the metal. Autogenous soldering, however, does not suffer from this defect. The metal is now being extensively used in place of lithographic stones. W. G. M.

1066. *Electrolytic Manufacture of Sodium and Potassium.* (Indus. and Iron, 26. p. 206, 1899.)—This is a description of an apparatus intended for the production of sodium, or potassium, lead alloys by the electrolysis of their halogen salts in the fused state. The anode compartment is separated from the kathode by a species of inverted bell, magnesia being employed as lining. A device for the circulation of the lead-sodium alloy is provided in order to ensure the absorption of the liberated sodium by the lead. The apparatus is explained by means of a drawing. O. J. S.

GENERAL ELECTRICAL ENGINEERING.

1067. *Primary Batteries.* **E. Petersen.** (Zeitschr. Elektrochem. 5. pp. 261–265, 1898.)—When $ZnSO_4$ is replaced by NaCl (1 in 4) in a Bunsen cell, the E.M.F. is raised 0·073 volt, and the resistance is the same as with H_2SO_4. The HNO_3 may be replaced, without serious loss of E.M.F. by $K_2Mn_2O_8$ (1 in 16), giving 1,678 volts; by 1 per cent. H_2O_2 with dilute H_2SO_4, 1,699 volts; by PbO_2 in dilute H_2SO_4, 1,991 volts; or by NaOCl (without free Cl_2), 2,021 volts; but these cells are inferior in constancy. The cell

$$Zn \mid NaCl\ (1 \text{ in } 5) \mid FeCl_3\ 6\ aq.\ (2 \text{ in } 1) \mid carbon$$

gives 1,720 volts and 0·3 to 0·4 ohm with moderate dimensions: a 4-in-1 solution of $FeCl_3$ with $\frac{1}{4}$ vol. NaCl (1 in 4) is recommended. The cell is constant for hours up to 1 amp.; when run down, it deposits iron on the carbon and gives 0·5 volt. One-fluid cells with Zn and C or Fe and C in $FeCl_3$ give 1·60 and 0·90 volts respectively, but are not constant. More constant are

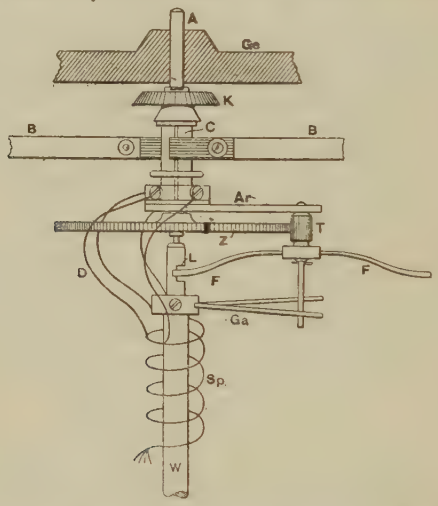
$$Zn \mid NaCl\ (1 \text{ in } 4) \mid K_3FeCy_6 \mid carbon$$

cells with E.M.F. 1·438 volts, sinking gradually to 1·105 as the ferri- turns to ferro-cyanide; resistance of medium size cells $\frac{1}{4}$ ohm. A new form of Daniell cell is described with copper gauze wrapped round a thin open sheet-lead cylinder containing the $CuSO_4$ crystals and a Zn plate in $MgCl_2$ (2 in 5) solution: the resistance is 0·4 to 0·5 ohm with 400 sq. cm. active surface and 2 cm. distance between the plates. B. B. T.

1068. *Accumulator Tests.* **P. Schoop** and **H. Benndorf.** (Elektrochem. Ztschr. 5. pp. 133–149 and 157–166, 1898.)—The paper contains a detailed account of tests carried out on 3 different types of secondary cells. It is pointed out that the relative merits of various types of cells cannot be arrived at from an investigation of their behaviour during a test, unless the particular purpose for which the accumulator is required is known. In the tests described an auxiliary electrode of cadmium was used, and the following quantities were observed, in the order given: (1) P.D. between cadmium and spongy-lead electrodes with current passing through cell; (2) also on open circuit; (3) P.D. between peroxide and cadmium electrodes when current was flowing through cell; (4) also on open circuit; (5) P.D. between terminals of cell; (6) E.M.F. of cell. All these results are tabulated, and plotted in the form of curves. A comparison of the cells as regards capacity, &c., is obtained by determining the capacity per kilogram-weight of cell in each case. The authors particularly insist on the advantage of using an auxiliary cadmium electrode, as by means of it it

is possible to determine which of the two plates gets exhausted sooner; such information may lead the manufacturers to considerable improvements in the construction of the cell. A. H.

1069. *Hiecke Electric Meter.* (Electrician, 42. p. 581, 1899.)—In this meter the motion of a hollow shaft or sleeve driven by clockwork and geared with the counting train through the bevel wheel, K, is controlled by an electric motor having its armature-shaft, W, concentric with the sleeve. The sleeve bears the commutator, C, and an arm, A*r*; at the end of A*r* is an arbor on which there is a pinion, T, gearing with a stationary concentric gear-wheel, Z, and also two arms, FF. These arms are adapted to



pass through a lateral slot, L, in the armature-shaft, W, at one point in the revolution of the shaft, thus enabling them to make a half-revolution corresponding to $\frac{1}{20}$-revolution of the sleeve and arm A*r*; the shaft W then moves $\frac{1}{20}$-revolution. Thus the shaft W and the arm A*r* each move through $\frac{1}{20}$-revolution alternately, the motion of the shaft W being limited by arms, *Ga*, acting on the end of the pinion shaft. By these means the rotation of the armature shaft W is rendered independent of the friction of the brushes B on the commutator C. C. K. F.

1070. *G. E. Regulator for Series Arc-Lighters.* (Elect. Rev. N.Y. 34. p. 28, 1899.)—The regulator consists of (1) a rotary oil pump driven by a belt from the armature shaft, and delivering oil to the valve chamber of (2) a cylinder with a radial partition and a rotary piston; (3) an electromagnet placed in the main

circuit and controlling, by its action on an armature, a balanced valve which admits oil into the cylinder on one side or the other (or both) of the rotary piston, thus causing it to move one way or the other (or to remain stationary); (4) a field rheostat forming a shunt across the field, with a number of contacts, over which moves an arm mounted on the axle of the rotary piston; (5) a toothed segment, supported by an arm projecting from the brush rocker, and gearing into a pinion also mounted on the axle of the piston. In maintaining constant current, the regulator performs two functions: it varies the resistance of the field shunt, and rocks the brushes one way or the other, so as to keep the spark-length at a minimum. This regulator is intended for use with 4-pole Brush arc-lighters, and is made by the General Electric Company. It is contained in a rectangular case placed directly beneath the commutator. A. H.

1071. *Alioth Alternate-current Radiators.* **R. B. Ritter.** (Électricien, 17. pp. 33–35, 1899.)—In these radiators, which are made by the Société d'Électricité Alioth, of Basle, the heat is generated in the object to be heated itself by means of Foucault currents. For this purpose solid plates of iron are subjected to an alternating magnetic field from bobbins traversed by the alternating current, copper rings being also embedded in these plates to promote this action. Various forms of heater constructed on this principle are described and illustrated. C. K. F.

1072. *Electric Light Switchboards.* **S. H. Sharpstein.** (Amer. Electn. 11. pp. 29–30, 1899.)—The author recommends automatic cut-outs, small marble panels, and easily removable apparatus; he also discusses separate exciter boards and 'bus bars. M.O'G.

1073. *Mnemonic for Conductor Resistance on Three-Wire System.* **W. H. Donner.** (Amer. Electn. 11. pp. 27–28, 1899.)

$$\text{Resistance in ohms per foot} = \frac{\text{Twice the allowable drop of volts.}}{(\text{the number of lamps}) \times (\text{the distance in feet.})}$$

A middle wire equal to the outer is recommended. M. O'G.

1074. *Electrolysis by Stray Currents.* **A. A. Knudson.** (Elect. Engin. N.Y. 27. pp. 228–230, 1899.)—Report to the Water Commissioners of Jersey City on the electrolysis of their water-mains. Excavations were made in two places, and the rails were found to be positive to the pipes by 10 volts and 15 volts respectively. From maps it was concluded that this current

would probably quit the pipes in a certain salt marsh, and take a short cut to the power station. Tests confirmed this. Of three parallel pipes traversing the marsh, the two outer ones were positive to the marsh by $\frac{1}{3}$ volt, and the inner one negative by 1 volt. In the presence of salt water this difference of potential will materially corrode the pipes. E. H. C.-H.

1075. *Prevention of Collisions at Sea.* **G. Dary.** (Électricien, 17. pp. 17–19, 1899.)—An invention by H. Herbert is described, in which two or more thermopiles are mounted on a vertical shaft capable of rotation; they are shielded so as to exclude all air currents, and all radiations, from the ship and from solar rays, whether direct or reflected from the surface of the water. The thermopiles are supposed to receive radiation from any approaching ship, and actuate relays of the d'Arsonval galvanometer type, ringing a bell when pointing in the direction of the approaching object. E. C. R.

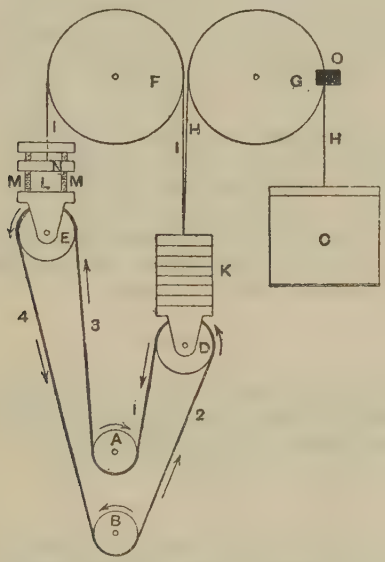
1076. *Electrical Apparatus on U.S. Battleships.* **F. W. Roller.** (Elect. Rev. N.Y. 34. p. 13, 1899. Paper read before the New York Electrical Society, November 14, 1898.)—In this paper the performance of the various types of electrical apparatus used on shipboard in the recent war is discussed. It was found that indicating apparatus of the galvanometer type was not satisfactory. The electric firing device for rapid-fire guns worked very well on the *Nashville*. Signalling was carried on by means of the "Ardois" apparatus, which consists of a string of four lanterns, each half clear glass and half red; inside each were two lamps, either of which could be illuminated independently, the different signal-combinations being obtained by means of a keyboard. The search-lights, motors for ammunition hoists, turret training, ventilating, fan driving, and steering gear worked well.

C. K. F.

1077. *Economic Test of a Boiler Feed-Pump.* **F. M. Wheeler.** (Mech. Eng. 2. pp. 873–874, 1898.) -It has been shown that the steam consumption of a duplex feed-pump will average about 120 lb. per I.H.P. hour, while in the U.S.A. battleship *Minneapolis*, some pumps consumed over 200 lb. of steam per I.H.P. per hour. The pump referred to in the paper consumed 52 lb. of steam per I.H.P. hour; the test was conducted by Messrs. Willans and Robinson, Rugby, and was for the benefit of the British Admiralty. The pump is a cross compound one; the valve gear is such that the low-pressure cylinder may be shut off, and the high-pressure side may act as a simple pump. The valve gear is fully described in the paper. As regards economy, this

particular pair of pumps with attachments weigh about half a ton, and handle about 17,570 lb. of feed water per hour. The power of the pump, working compound, was 5·6 I.H.P. On the basis of a saving of 70 lb. weight of steam per I.H.P. per hour over and above what would be used in a duplex pump, a total saving of steam of about 393 lb. per hour, or about 50 lb. of coal per hour is effected. This gives a total saving of 1,200 lb. of coal per twenty-four hours. A. S.

1078. *Electric Elevators.* **A. E. B. Ridley.** (Mech. Eng. 3. pp. 58–60, 1899.)—In this article, the Sprague-Pratt and Ward-Leonard elevators are briefly described, together with one designed by E. M. Fraser, wherein all gearing has been eliminated and the motors are never reversed, the brake being used only for braking the car. In this elevator, of which a diagram is given,



pulleys on the shafts of two motors, A B, act on loops on an endless rope, 1, 2, 3, 4, whilst in other loops are idler pulleys, E D, attached to an adjustable frame L, and a counterweight, K, respectively, and both movable vertically in guides. C is the car and O a brake clutch. If A rotates faster than B, D moves down and the car C up; whilst if B rotates faster than A, D moves up and the car C down. By varying the speeds of A and B, the car can be made to move up or down or to stop as desired. C. K. F.

1079. *Efficiency of Electric Pumps.* (Elect. Rev. N.Y. 33. p. 380, 1898.)—A test was made on a Worthington horizontal triple

pump driven through spur gearing by two 65 H.P. alternating current motors. The speeds of motor and pump respectively were 450 and 45 revolutions per minute. The tests were made at constant speed and variable loads, and were under the supervision of disinterested engineers. Curves are plotted from the observed data; the combined efficiency from switchboard to the water column is nearly 70 per cent. at the greatest load; which is thought to be remarkably good, considering that the water end of the pump had six plungers, and that the pump had just come from the shop. A. S.

1080. *Hyatt Roller Bearing.* (Frank. Instit. Journ. 147. pp. 145–150, 1898.)—The Franklin Institute recommends the award to John W. Hyatt of the John Scott Legacy Premium and Medal, for his invention of the elastic spiral anti-friction roller. The Committee on Science and the Arts investigated the merits of the Hyatt Roller Bearings, and found that in all cases the rolling resistance was less than that of solid rollers. This they attributed to the fact that the solid rollers have only contact at one or two points along the length, and show signs of grooving at the points of contact; while under the same conditions the spiral rollers show a complete bearing throughout their entire length, the elasticity of the roller permitting it to follow the sinuosities of the plate. The Hyatt roller resembles a closely wound spiral spring, made from a strip of steel of rectangular section: the roller consequently has all the flexibility of a spring. A. S.

1081. *Waste of Fuel.* **F. Bruton.** (Electricity, N.Y. 15. pp. 310–311, 1898.)—Short practical notes upon the way in which fuel is apt to be wasted in central stations. W. R. C.

1082. *Electric Timber Seasoning and Preservation.* (Elect. Engin. 23. p. 143, 1899.)—This process consists in forcing a solution of 10 per cent. of borax, 5 per cent. of resin, and 5 per cent. of carbonate of soda, heated by a steam coil, through wood by means of a current of about 600 amperes at 110 volts, by electric endosmose for from five to eight hours, and then drying at a temperature of 75°. The current required is 18 amperes per cubic foot. The inventors are Nodon and Bretonneau.
C. K. F.

GENERATORS, MOTORS, AND TRANSFORMERS.

1083. *Limit of Sparkless Commutation.* **G. Kapp.** (Elektrotechn. Ztschr. 20. pp. 32–35, 1899.)—From theoretical considerations regarding the energy stored up in an armature coil, and the peripheral width of the field due to the short-circuited coils, the author deduces the following two formulæ, which represent the necessary and sufficient conditions for sparkless running :—

$$B_a = C_o \frac{\Delta}{n} \text{ and } 1 = C_1 \frac{\delta}{R} \cdot \frac{S}{1+n},$$

where B_a is the induction in air-gap, Δ = flow of current in armature conductors per unit length of circumference; n = number of commutator segments covered by a brush; δ = length of air-gap; R = radius of armature; S = number of segments in commutator. C_o and C_1 denote two constants, whose values—as deduced from experiments carried out by the author and others—are as follows :—

$C_o \geqq 12$ for smooth-core gramme armatures
$C_o \geqq 24$ for toothed-core gramme armatures
$C_o \geqq 9$ for smooth-core drums
$C_o \geqq 15$ for toothed-core drums
$C_1 \leqq 0{\cdot}4$ for metal brushes
$C_1 \leqq 0{\cdot}8$ for carbon brushes

(See also Electrical Engineer, 23. pp. 198–200, 1899.)

A. H.

1084. *Theory of Commutation.* **E. Arnold** and **G. Mie.** (Elektrotechn. Ztschr. 20. pp. 97–101, 136–138, and 150–152, 1899.)—A very elaborate mathematical theory of the process of commutation. The main results arrived at by the authors are the following : A necessary condition for sparkless commutation is $\frac{R_1 T}{L} > 1$, where R_1 is the contact resistance of the brush, L the inductance of the coil in the position of short-circuit, and T the duration of the short-circuit. Commutation takes place best when $e_T = I(R_s + 2R_v \frac{\beta}{b} + 2R_1)$, where e_T is the reversing E.M.F. at the instant when the coil is open-circuited, I = normal current in each armature conductor; R_s = resistance of short-circuited coil; R_v = resistance of connectors between coil and commutator segments; β = width of segment; b = width of brush contact. When this condition is fulfilled, the rate of change of the short-circuit current at the instant of open-circuiting is zero. Solutions of the differential equation of the short-circuit current are obtained in the form of power-series and hypergeometric series, and curves of the short-circuit current are plotted from these for a number of cases. The energy-transformations

during the time of short-circuit are next discussed. It is shown that if commutation proceeds properly, the inductance of a coil does not give rise to dissipation of energy; the stored energy ($\frac{1}{2}LI^2$) becomes mostly converted into mechanical energy during the time when the initial current in the short-circuited coil is diminishing to its zero value. The current in the short-circuited coil, in fact, causes it to act as a motor until zero value of the current is reached. This conclusion is contrary to the hitherto generally accepted view—due to Joubert—that during the time of short-circuit the whole of the stored energy ($\frac{1}{2}LI^2$) is dissipated. This latter view would only be correct in the special case where the coil is moving in a field of zero intensity during the time of short-circuit; in which case sparkless running becomes impossible, and the stored energy of the coil is entirely dissipated in causing sparking and heating. Approximate methods of calculating the inductance of armature coils for both smooth and toothed cores are developed, and some useful practical deductions are given towards the end of the paper. The maximum value of I (the current carried by a single conductor) in toothed armatures should not exceed 150 to 180 amperes. If C = total number of external armature conductors, s = number of commutator segments, then for toothed armatures—

$$s \geqq \cdot 04C\sqrt{I}.$$

A. H.

1085. *Hunting of Paralleled Alternators.* **G. Kapp.** (Elektrotechn. Ztschr. 20. pp. 134–136, 1899.)—It sometimes happens that alternators, which may be paralleled without difficulty, and which for a time will run in parallel without giving any trouble, exhibit the phenomenon of "hunting." The ammeters of the machines show, by the gradually increasing amplitude of their swings, that heavy equalising currents pass between the machines. Under certain conditions these currents may increase so far as to give rise to pulsations in the P.D. across the 'bus bars, or even to blow the fuses. These phenomena are only exhibited by direct-driven steam alternators, and are absent in belt-driven machines or those driven by turbines. On the other hand, it may happen that an alternator, driven by a steam engine giving a very uniform torque, hunts more strongly than another whose engine gives a much less uniform torque. Hence the action cannot depend *solely* on the degree of uniformity in the torque. Further, the fact that hunting has frequently been observed to develop very gradually suggests a species of resonance. Resonance, however, implies oscillations. Imagine an observer bound to a fly-wheel which revolves with constant angular velocity, and which is placed in front of the engine fly-wheel. If the latter revolves with constant velocity equal to that of the first fly-wheel, it will appear stationary to the observer. If, on the other hand,

its velocity fluctuates between certain limits, it will appear to oscillate to and fro. Similar oscillations will take place between two rotating vectors, one of which, corresponding to the 'bus bar P.D., revolves with constant velocity, while the other, corresponding to the E.M.F. of the machine considered, revolves with varying velocity (the projections of the vectors on a fixed straight line representing the instantaneous values of the E.M.F.s). Consider the instant when the machine vector V_m passes its normal position relatively to the 'bus bar vector V_b in the positive direction. At this instant, the power developed by the machine is the precise equivalent of the power impressed on it by the engine (there being no acceleration). But since the speed of the machine is at its maximum, the vector V_m gains on V_b until the average speed is reached; at this instant, however, the output of the machine is in excess of the power which it receives from the engine, on account of the forward position of the vector V_m. Hence V_m is retarded until it reaches its normal position, and the output of the alternator is once more the equivalent of the engine power. The speed of V_m is now at its minimum, and it falls behind V_b, the load on the alternator diminishing and its speed increasing until the normal speed is reached. At this instant the output is less than that corresponding to the power of the engine, and acceleration takes place until the vector V_m once more reaches its normal position, and is on the point of passing V_b. The changes here described constitute a complete oscillation of the alternator armature. If the torque exerted by the prime mover were perfectly uniform, oscillations of this description if started (as, *e.g.*, by quickly closing and opening a circuit) could not last long, as they would be rapidly damped out by mechanical, magnetic, and electrical dissipation of energy. If, however, the impulses exerted by the engine follow each other at intervals equal to the period of oscillation of the armature, and if these impulses are sufficiently strong to cover the losses which damp the oscillations, the latter will persist. If the impulses are somewhat stronger, resonance takes place, and the evil is aggravated. It is thus obvious that the most important factor which determines the hunting is the ratio of the period of engine impulse t_e to the period of oscillation of the alternator armature t_a. If the ratio t_a/t_e assumes or approximates to one of the values $\frac{1}{4}$, $\frac{1}{3}$, $\frac{1}{2}$, 1, 3, 5, trouble may be expected. t_e is at once readily determined from the construction and speed of the engine; t_a is shown by the author to be approximately equal to

$$2\pi\sqrt{\frac{18{\cdot}4\ c\ i}{v\ d\ m}},$$

where c stands for P.D. between 'bus bars; i for the short-circuit current of the alternator armature corresponding to normal excitation; v for the peripheral velocity, in metres per second; d for the pitch of the pole-pieces, in metres; and m for the

moment of inertia of rotating part of machine, divided by its radius (kg. and metre as units). In most cases, $t_a > t_e$. If t_a/t_e is found to have a dangerous value, the following expedients may be used to prevent hunting: (1) surrounding pole-pieces by heavy copper rings; (2) increasing or decreasing weight of fly-wheel; (3) inserting a choking-coil between the alternator and the 'bus bars; this last expedient is the cheapest, and has the same effect as increasing the moment of inertia of the rotating part. It is important to notice that under certain conditions a slight increase in the moment of inertia, so far from curing hunting, may aggravate it. A. H.

1086. *Compounding of Alternators.* **E. Danielson.** (Elektrotechn. Ztschr. 20. pp. 38–39, 1899.)—The article contains an

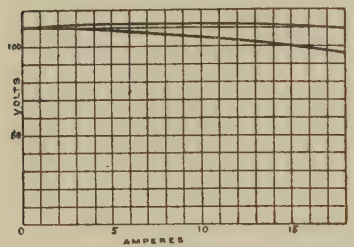


FIG 1

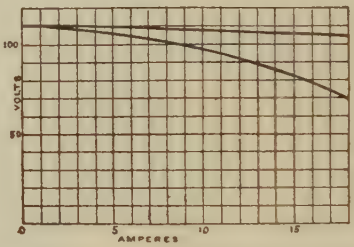


FIG 2

illustrated description of a machine built on the plan recently patented by the author; this has already been noticed in a previous abstract (see 1898, Abstract No. 862), and the machine illustrated in the present article is constructed precisely as shown by the sketch there given. Some interesting results obtained with this machine are embodied in the accompanying curves, the lower curve in each case giving the characteristic corresponding to constant field excitation, and the upper one the characteristic with the compounding device in action. The curves in Fig. 1 refer to a non-inductive load, those in Fig. 2 to an inductive load of power-factor 0·8. A. H.

1087. *Alternating Current Motors.* **E. J. Berg.** (Amer. Electn. 11. pp. 17–19, 1899.)—This article deals chiefly with synchronous motors, and points out that such motors do not work well on high-frequency circuits or from direct-driven generators. For synchronous motor-working the generators should, if worked by steam power, be belt-driven. W. G. R.

1088. *Induction Motors.* **W. Baxter, Jr.** (Amer. Electn. 11. pp. 121–123, 1899.)—This is an attempt to explain in a popular manner the way in which energy is transferred from the primary to the secondary in induction motors with squirrel-cage rotors. The explanation is based upon the assumption of a magnetic field of constant strength rotating with uniform angular velocity, and depends upon the relative angular velocities of the field and the rotor windings. W. G. R.

1089. *Speed Variation of Alternate Current Motors.* **W. G. Rhodes.** (Elect. Rev. 44. p. 107, 1899.)—The author draws attention to the fact that alternating current motors would probably come into more general use if some combined voltage and frequency transformer were invented which would enable the speed of such motors to be varied. A. H.

1090. *Rectification of Alternate Currents.* **L. Kallir.** (Zeitschr. Elektrotechn. Wien. 16. pp. 602–604, and 613–615, 1898.)—The author discusses the various arrangements of

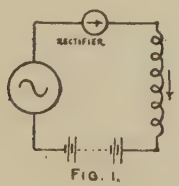


FIG. 1.

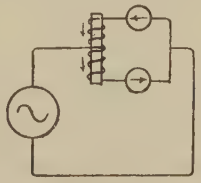


FIG. 2.

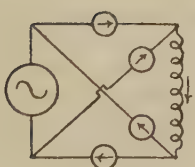


FIG. 3.

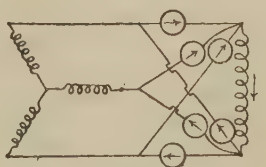


FIG 4.

circuits which may be adopted in connection with rectifiers having no moving parts—such, *e.g.*, as the electrolytic rectifier of Graetz and Pollak (see 1898, Abstract No. 207). In each case the equation to the current is fully worked out. The cases considered by the author are shown in the annexed sketches. The arrow affixed to each rectifier indicates the direction in which the current is allowed to flow. The arrangement shown in Fig. 1 is not to be recommended, as the current varies a great deal, reaching a zero value during each period. The connections

of Fig. 2 might with advantage be used for exciting the field-magnet of an alternator: the pulsations of the current are extremely slight. Fig. 3 shows an arrangement due to Graetz and Pollak, the characteristic feature of which is the utilisation of *both* half-waves of the alternate current; the pulsations in this case, with a reasonable amount of inductance in the circuit, are also slight. Lastly, Fig. 4 is an arrangement adapted to a three-phase circuit; the current may in this case be rendered remarkably constant. A. H.

1091. *Theory of Rotary Converters.* **G. Kapp.** (Électricien, 17. pp. 1–4, 21–24, 73–75 and 88–90, 1899, also Elek. Zeits.)—This is a mathematical discussion of the rotary converter. The following numerical results are given :—

E.M.F. of the alternating current for 100 volts continuous at motor brushes.		Nature of Current.
$\frac{2}{3}$	$\frac{1}{2}$	
75	82	One phase.
75	82	Two phases.
65	71	Three phases.
53	58	Four phases.
37	42	Six phases.

The $\frac{2}{3}$ and $\frac{1}{2}$ at the head of the columns correspond to the two usual constructions, that is to two sizes of pole-pieces which are equal respectively to $\frac{2}{3}$ and $\frac{1}{2}$ of the interval between two poles. The figures given refer to light load voltage.

The chief point considered is the losses as compared with other electrical machines. The following *résumé* of results is given: "Converters of three, four, and six phases have only been considered for the case of zero phase difference of current and electromotive force. The calculation of the power absorbed when there is a phase difference can be performed in the same way as for a single-phase converter, but the process is tedious and the result of little value. For practical applications it is not necessary to determine with great accuracy the copper losses for the case of phase difference between current and electromotive force, because the excitation is always so chosen that at full load this phase difference is zero. For small loads there may be phase difference, but the consequent increase in the copper loss is not of great importance, because the load, and therefore the actual loss, is but small. In the following table the power, in the case of a difference of phase, is determined by taking $\frac{\eta}{\cos \phi}$ as a factor of c, where η is the ratio of the maximum value of the alternating current to c, and c is half the value of the continuous current. For a monophase converter the value thus obtained is accurate. For

converters of three, four, or six phases it is very approximate." In order to make the following table complete, there has been added the values obtained by Steinmetz for the limiting case, corresponding to a field which follows a sine law.

Power of a Rotary Converter, expressed in per cent. of the Power which it will furnish for Equal Copper Losses in the Armature as a Continuous Current Generator.

Type of Converter.	Power Factor.	Theoretical Limiting Case (Steimnetz).	Size of Pole-piece.	
			$\frac{2}{3}$	$\frac{1}{3}$
Single phase...	$\cos \phi = 1$	85	88	95
	$\cos \phi = 0{\cdot}9$		81	88
	$\cos \phi = 0{\cdot}8$		73	80
	$\cos \phi = 0{\cdot}7$		63	70
Three phases	$\cos \phi = 1$	134	138	144
	$\cos \phi = 0{\cdot}9$		128	137
	$\cos \phi = 0{\cdot}8$		117	126
Two or four phases	$\cos \phi = 1$	164	167	170
	$\cos \phi = 0{\cdot}9$		160	167
	$\cos \phi = 0{\cdot}8$		144	153
Six phases.....	$\cos \phi = 1$	196	198	199
	$\cos \phi = 0{\cdot}9$		192	196
	$\cos \phi = 0{\cdot}8$		177	188

W. G. R.

POWER DISTRIBUTION, TRACTION, AND LIGHTING.

1092. *Electrical Equipment of Refrigerating Plant.* (Amer. Electn. 40. pp. 1–5, 1899.)—The lighting, ventilating, elevating power and partial pumping service for the Manhattan Refrigerating Co.'s New York storage and distributing plant is entirely electrical. Within the building, the refrigerating medium is brine circulated by steam pumps, but for the central station service to the adjacent market stalls liquid ammonia is used. The ammonia pumps are steam-driven, but the brine and water pumps are worked in pairs by 20 H.P. belted motors at 250 volts, which have to operate in the wet. Switches and contacts are silver-plated, to prevent chemical action with the ammonia or salt-laden atmosphere. Walls and ceilings being frequently snow-covered, special precautions had to be taken with conductors, which are twin-rubber and lead-covered, laid in steel pipe with outlet boxes filled solid with paraffin. Lampholders are of the porcelain waterproof type, hung by twisted cable from the outlet boxes. To get over difficulty with shocks from damp switches, a novel form of enclosed switch is used, consisting simply of a glass tube stoppered at both ends and containing a globule of mercury. When tilted in one direction the mercury joins the iron terminals, which pass through one of the stoppers. Forty 12-inch motor-fans are used for maintaining an even temperature throughout the storage rooms. A specially designed hanging waterproof bell has to be used with the telephones on account of the prevalent moisture.

E. H. C.-H.

1093. *City of London Electric Lighting Station.* (Elect. Rev. 44. pp. 337–340, 382–383, and 421–425, 1899.)—An account is given of this well-known station, which now contains plant to the extent of 11,660 kw., the two largest units (by Ferranti) being 1,500 kw. each.

W. R. C.

1094. *Power Station at Pittsburg.* **G. F. Greenwood.** (Elect. World, 33 pp. 203 205, 1899.)—The consolidated lines were found to require a station capacity of 6,000 kw., which was divided among six machines. Slow-speed horizontal engines were chosen as occupying less floor space than vertical engines. Their 20-feet fly-wheels weigh 100,000 lb. Coal is handled by conveyors which can deal with 40 tons per hour, and take 15 H.P. to operate. Each battery of water-tube boilers has a separate iron stack, 147 feet high by 5 feet 6 in. diameter. This is more economical in money and space than a single large stack. The switchboard is so arranged that any dynamo may be run alone or in parallel with others, with either its positive terminal

to one 'bus bar, and its negative to ground, or with positive to ground and negative to another 'bus bar, while any feeder of the system may be connected to either 'bus bar. This corresponds to a 1,100 volt-system, and gives a smaller drop and greater freedom from electrolysis, due to the fact that large current does not return to the station through the ground, but distributes itself over a large area of the city, thus decreasing the necessary investment in ground wire. The disadvantages are complication of the switchboard and the necessity of having special 1,100 volt circuit-breakers on the lines, since failure of one of these breakers would produce a short circuit. A regulating storage battery is used. A novel feature is the interlocking pneumatic switchboard, somewhat similar to that at the Cataract Company's Station at Niagara Falls. E. H. C.-H.

1095. *Pittsburg Power Station and Shops.* (Street Rly. Journ. 15. pp. 127–140, 1899.)—This article contains a detailed and fully illustrated description of the power station, repair shops, and equipment of the Consolidated Traction Company's lines in Pittsburg. (See preceding Abstract.)

The repair shops are fully equipped with tools, travelling crane, traversers, dismantling pits, &c., all operated electrically. A pair of wheels, or both axles with their motors, can be removed from the truck, and a new set substituted in twenty minutes by five men. Wheels are ground by a Murphy wheel grinder without removing them from the car. Compressed air at 60 lb. is used for blowing out motors, cleaning car cushions, &c. Each of the 120 new cars carries two 50 H.P. motors, with electric brakes on motor cars and trailers. E. H. C.-H.

1096. *Blackburn Electric Tramways.* (Elect. Engin. 23. pp. 334–340, 1899.)—The Siemens dynamos are arranged with two commutators normally connected in series for traction work, but put in parallel for connection on to the lighting 'bus bars in emergencies. Instead of the usual guard wires over the trolley line, the Telephone and Post Office authorities have sanctioned wire cradles underneath their own wires. English-made motors and controllers are used and a special form of trolley head and support. E. H. C.-H.

1097. *Detroit Interurban Electric Railways.* (Street Rly. Journ. 15. pp. 1–8, 1899.)—There are six lines going out from Detroit, 20 to 40 miles each. Cars run at the side of the highway at 30 to 40 miles per hour with 30 minutes' headway. The lines are divided into 5-cent zones, the average fare being 1 cent per mile. The system is 500–650 volts, with boosters for long lines. One of the latest lines uses 500 H.P. units, 250 H.P.

Babcock boilers, with mechanical stokers and draft. Another uses a special arrangement of forced draught producing a 5-oz. pressure at the expense of 2 per cent. of the output from the boilers. Rigid brackets in the overhead work have been discarded on account of wire breaking at the hangers. Long, heavy cars are used, some over 50 feet. Each has a baggage and smoking compartment, and some carry state rooms, with lavatory, water cooler, &c. One line has applied the Westinghouse air-brake with automatically controlled motor and compressor. Two 75 H.P. motors are preferred to four 50 H.P. motors.

E. H. C.-H.

1098. *Argentine Electric Tramways.* (Street Rly. Journ. 15. pp. 69–74, 1899.)—Horses and fodder are cheap and coal is expensive (6·50 dollars per ton), yet electric traction pays and is being extended. The power station of La Capital Tramways Company contains 450 H.P. Ball-Walker units, Stirling boilers, and Sturtevant induced draught apparatus. The heavy ox-carts, which weigh 15 tons and have 10-feet wheels, snap off tie-rods on country roads; braced tie-plates are now being used.

E. H. C.-H.

1099. *Cross-Country Line at Lewiston, U.S.A.* (Elect. World, 33. pp. 255–258, 1899.)—The main line of the Lewiston, Brunswick, and Bath street railway extends 30 miles from Lewiston to Bath, with urban branches at both ends, making a total of about 60 miles. Power for the whole line is obtained from falls near Brunswick, where 1,000 H.P. has been leased for 10,000 dollars per annum. Four Victor turbines, under 17 feet head, with Lombard governors, are all mounted on the same shaft, which drives the main countershaft by rope. Three 250 kw., double-current, Westinghouse generators are driven by clutch-pulleys on the countershaft. The whole 250 kw. may be delivered through the commutator at one end of the armature, or taken as alternating current from collector rings at the other end, or in any proportion from both ends simultaneously. Speed is 600 revolutions per minute, frequency 60, direct current voltage 550, and three-phase voltage from the same windings 330. The machines are practically rotary converters, with an added pulley and outer bearing. They are compound-wound. The direct current panels of the switchboard are of the usual pattern; the three-phase generator-panels carry an ammeter on each phase, a triple-pole switch, and a special field resistance with fine adjustment. The three-phase current is transformed in a separate building to 10,000 volts by Westinghouse, oil insulated, self-cooling, 125 kw. transformers, with tappings so arranged that different numbers of turns can be cut off from one end of the low tension winding, thereby enabling the ratio of transformation to be changed by $6\frac{1}{2}$, $12\frac{1}{2}$, or $18\frac{3}{4}$ per

cent. The 10,000 volt switches consist of plugs on the end of 3-feet wooden poles with flexible connections. The plugs enter brass sockets with spring contacts on marble slabs. The fuses consist of a foot of aluminium wire in soft rubber tube, supported on triple-petticoated porcelain insulators. Of the two high-tension lines one runs 10 miles and the other 20, to rotary sub-stations. The converters are 10-pole machines at 720 r.p.m., with practically the same windings as the generators. They carry at one end small three-phase induction motors for starting the rotary, the motor being wound to give a high torque at standstill, and having a smaller number of poles than the rotary, so that it will bring the speed slightly above sychronism, giving a good opportunity for closing the main switch while passing the critical point.

E. H. C.-H.

1100. *Stansstad-Engelberg Polyphase Railway.* (Electrician, 42. pp. 460–465, 1899.)—The metre-gauge line is laid with 52-lb. Vignoles rails with steel sleepers. In parts a ladder rack is used, the first and last section of which are supported on strong conical springs, and have revolving teeth to prevent the pinions mounting. The bonded rails form the third wire of the three-phase system. Radial-flow high pressure Pelton wheels are direct-coupled to three-phase generators with revolving armatures. With a head of 1,250 feet, the output of each set is 180 H.P. The shunt-wound exciters are driven by 12 H.P. turbines at 750 volts without governors. Three 30 kw. transformers behind the switchboard raise the voltage to 5,200. An automatic switch is arranged to interrupt the exciter current in case of an earth on the high-tension line. The two trolley wires of 7·5 mm. diameter are suspended 3 feet apart on span wires. The high-tension line is carried on the outer side of the poles which also carry the low-tension feeder lines, fed from three single-phase transformers at a midway station. The State telephone line runs parallel to the railway, but buzzing is heard only on wet days. At one point the line crosses the main road by a drawbridge, and at another it crosses a direct current tram line.

The 46-feet bogie motor cars weigh 14 tons empty, and carry 46 passengers, with luggage and mails. The front bogie carries two 35 H.P. 750-volt induction motors, running at 480 revolutions per minute and driving through single reduction gearing. Current is collected by two double sliding contacts. The stator current is controlled on the driver's platform by a two-way switch, under which are placed four enclosed high-tension fuses for the stator circuit of both motors. The third end of the stator winding is connected to the bogie frame. The rotor current is collected by double carbon brushes from the slip-rings, from whence it passes to the rotor resistance placed on the roof. The resistance is worked by a lever placed above the controller on the driver's platform. The cars are heated and lighted electrically, current

for the lighting being supplied at 100 volts by a small transformer placed in the luggage compartment. The heaters are placed, seven in series, under the seats, and are connected directly to the 750-volt line. Each car is fitted with two brakes: the one is a powerful hand-brake applied to all the eight wheels of the car, the second is a pinion brake acting on the pinion placed on the rear bogie, and is only used when the car is running over the rack. The maximum speed for which the cars are designed is 12½ miles an hour; the speed is only varied by means of a rheostat in the rotor circuit.

The 12-ton locomotives carry two induction motors giving 75 H.P. at 650 revolutions, and each weighing two tons. Both motors are geared to a common shaft, which is again geared to the driving pinion running in the rack. The gearing is so dimensioned as to give the locomotive a speed of 3·1 miles an hour on the rack. By means of a friction coupling and connecting-rod the motors can be connected to the driving wheel, making it possible to run the locomotive at a speed of 7½ miles an hour on the adhesion line. The rotors are controlled by a reversing switch in the stator circuit and a resistance in the rotor circuit. Three independent brakes are in use. The first is a hand-brake acting on the driving wheels; the second is a hand-brake, acting by means of four gun-metal shoes pressed on two wheels keyed to the driving pinion; the third is an automatic brake, which acts as soon as the speed of the locomotive exceeds 4½ miles an hour on the rack. The latter consists in the main of a centrifugal governor keyed to the motor-shaft; this releases a weight, which in its fall opens the switch in the stator circuit and couples the brake spindle to the motor-shaft, so tightening the brake shoes on the brake pinion and on a pinion placed loose on the rear axle of the truck. By means of this brake it is possible to stop a train weighing 28½ tons, and going at a speed of three miles an hour, on the 25 per cent. gradient in a distance of 20 feet. The motor cars will draw a trailer up a 2·3 per cent. gradient at 12 miles per hour; while, on the rack, the locomotives push the car up at 3 miles per hour. In descending, the speed of the motors tends to rise above synchronism, and the current given back to the line then makes the turbines race, unless a car is going up or a water resistance is put into the generator circuit. Extensions to 600 H.P. capacity are contemplated. (See also 1899, Abstract No. 936.) E. H. C.-H.

1101. *Graphical Solution of Traction Problems.* **J. Neidt.** (Elektrotechn. Ztschr. 20. pp. 39–43 and 57–59, 1899.)—The first part of the paper deals with the problem of determining the velocity of a tram-car at every instant when the resistance in the motor circuits at starting is varied in such a manner as to maintain a constant current through them which will produce the greatest possible tractive effort—the wheels being just on the

point of skidding. The acceleration will then be constant, and the velocity will increase in simple proportion to the time; this will go on until the whole of the starting resistance has been cut out, the motors being in parallel. Any further increase of speed will result in a reduction of the current, and a consequent decrease in the acceleration. The law connecting speed and torque of motor is given by its mechanical characteristic; for the problem in hand, it is convenient to plot a curve connecting total pull with speed of car. Instead of supposing that the pull decreases steadily with the speed, it is assumed that it decreases by sudden jumps or steps; during each step (*i.e.*, between two given limits of speed) the acceleration is taken to be constant. This assumption enables us to obtain (approximately) a number of points on the time-speed curve, and so to construct the entire curve. The frictional resistance due to the rails and air resistance must, of course, be subtracted from the total pull to get the accelerating pull. With frequent stoppages, it is essential to use motors giving rapid acceleration. Examples are given of the advantages of rapid acceleration. In the second part of the paper the author deals with the graphical determination of the starting resistances, and the resistances to be used in the motor circuits when their generator action is used for braking purposes. A. H.

1102. *Guest Closed Conduit System.* (Elect. Engin. N.Y. 27. pp. 205–206, 1899.)—All the apparatus is contained in 4-inch by 3-inch channel iron, laid as a continuous central conduit. The cover to this conduit is bolted on in sections, insulated from the conduit and from each other, and carries all the working parts. Iron induction plugs are secured at frequent intervals in the cover, from which they are magnetically insulated. The only electromagnet is carried on the car, is energised by the motor current or by cells, and operates, by induction through the plugs, on a pendulous armature which connects the section of cover-plate on to the feeder. A few series-turns round the plugs ensure firm contact when once the cover-plate is alive. When the car and its magnet move on, the pendulous armature drops and breaks contact between feeder and cover-plate. E. H. C.-H.

1103. *Motor-Cars in New York.* **G. H. Condict.** (Elect. World, 33. pp. 261–262, 1899.)—In the recent blizzard, the motor-car proved its usefulness by operating when all horse traffic was stopped. The greatest difficulty at present is with tyres. All kinds have been tried on the New York electric cabs, but a satisfactory one has not yet been obtained. Rear pneumatics and front solids are advantageous. E. H. C.-H.

1104. *Electric Lighting of Country Houses.* **B. M. Drake.** (Elect. Engin. 23. pp. 141–143, 1899. Paper read before the Royal Institute of British Architects.)—A brief comparison of the various kinds of generating plant (steam, gas, and oil engines, &c.) is given, and practical hints as to plant, cost, &c. The artistic illumination of rooms is also considered. W. R. C.

1105. *Thomson-Houston Enclosed Arc Lamp.* **T. Pausert.** (Écl. Électr. 18. pp. 91–99, 1899.)—In this article, descriptions, accompanied by photographs and diagrams of connections, are given of continuous current lamps with simple winding, with differential winding, and with the regulating coil arranged concentrically around the upper carbon-holder; and of an alternate current lamp. Short descriptions are also given of lamps arranged for special purposes. Various forms of nipper or tong clutch are shown, actuated by linkwork from the core or cores of the regulating solenoid or solenoids. The alternate current lamp has a reaction coil provided with a number of terminals, so as to enable the lamp to be worked at frequencies of 42, 50, 83, or 100 periods per second, and at pressures ranging from 98 to 120 volts. Lamps for working in series on high tension alternate current circuits are also described, in which there are no reaction coils, the lamps being fed through a special transformer, in which the primary coil is fixed, and the secondary coil can approach or recede therefrom. This motion is automatic, so as to keep the current in the secondary circuit absolutely constant. For this purpose the coils are enclosed in a casing filled with oil, and the secondary is supported by counterweights so that at full load the secondary coil is close against the primary, and the electromotive force in the secondary is a maximum, at other loads the secondary coil taking up a position corresponding to the resistance in the secondary circuit. These transformers are made for 25, 50, 75, or 100 lamps.

The inner globes of the lamps cost 1·20 fr., and require to be replaced at the end of 400 hours' lighting, *i.e.*, 1·20 fr. per month for two lamps; the consumption of carbon 25 cms. per 100 hours, *i.e.*, 0·60 fr. per month for two lamps; for lighting 7 hours per day, the cost of attendance for two lamps is 1 fr. per month. Total for maintenance is thus 2·80 fr. per month. C. K. F.

TELEGRAPHY AND TELEPHONY.

1106. *Siphon-recorder Signals.* J. Rymer-Jones. (Elect. Rev. 44. pp. 36–38, 77–79, 191–194, and 484–486, 1899.)—The shape of signals received and recorded by a siphon-recorder for a given cable depends upon a great many conditions and adjustments of instruments both at the sending and receiving end of the cable. The author gives about two hundred examples of actual "recorder slip" obtained by himself and E. Raymond-Barker on a particular siphon-recorder under different conditions of working through a long artificial cable. The various factors considered are: (1) Capacity of "signalling" condensers at the "sending" end; (2) Capacity of "signalling" condensers at the "receiving" end; (3) Speed of transmission; (4) Battery power; (5) Shunts of recorder coil; (6) High-resistance shunts connected so as partially to short-circuit the "signalling" condensers; (7) The effect of using condensers of low insulation; (8) The effect of artificial "leaks"; (9) Length of cable. An automatic transmitter was used, and the speed was varied between 16 and 25 words per minute. It is impossible to describe the results without referring to the 216 recorder "slips," but a few points may be noted. For short cables, a signalling-condenser at one end only is a better arrangement than signalling-condensers at both ends. The falling-off of signals towards the zero-line can be modified by adjustment of the bifilar suspension, or by shunting the signalling condensers at either end. Increasing the capacity of the signalling condensers at both ends of a long cable increases the amplitude; but above a certain capacity the "definition" is not improved. Signals may generally be improved by a proper proportioning of the capacity of the "sending" to that of the "receiving" condensers. Altering the speed may change the shape as well as the size of signals. When signalling-condensers are used at only *one* end of the cable, the effect of shunting them with a high resistance is to make the signals rise as a whole from the zero-line; the effect of condenser-shunts, when signalling-condensers are used at *both* ends, is to make the signals fall away from the zero-line. The high insulation of signalling-condensers is of importance only when the cable is subject to strong and varying earth-currents; in other cases, condensers of low resistance may tend to improve the shape of signals. The effect of low insulation in the cable itself is to cause the signals to fall towards the zero-line; this fall may be partially compensated by the use of signalling-condensers of low resistance. The effect on the amplitude of signals of a "leak" in the cable is a maximum when the leak is at the middle of the cable.

[All the results were obtained using the artificial cable, neglecting self-induction; to this extent they may differ from the results of ordinary cable-working.] R. A.

1107. *Relay-transmitters.* **E. Lönnqvist.** (Journ. Télégraph, 23. pp. 6–10, and 25–29, 1899.)—A description with illustrations is given of the arrangement of telegraphic apparatus adopted by the Director-General of Swedish Telegraphs. It includes an account of the relay-transmitter system introduced recently into Sweden. R. A.

1108. *Lodge and Muirhead's Syntonic Coherer Telegraph.* **J. Blondin.** (Écl. Électr. 18. pp. 81–86, 1899.)—Other things being equal, a resonating receiver will respond to weaker waves, and therefore at greater distances than a non-syntonic one. The Righi spark-gap prevents the coil from seriously affecting the periodicity at the sending end and at the receiving end, as the receiver is normally a non-conductor. The author thinks Lodge's precautions in connecting the resonator to it are of little use. Turpain's connections of '95 are said to be almost identical with Lodge's. Tietz's experiments confirm the value of a condenser in the earth connection. Turpain studied in '95, and published some months before Lodge, a system of Hertz waves transmission on telegraph networks. M. O'G.

1109. *Wireless Telegraphy.* **W. Bissing.** (Elect. World, 33. pp. 55–57, 83-86, 110–111, 1899.)—In this series of illustrated articles a precise account is given of the history of electrical methods of telegraphing without line wires, from the experiments of Lindsay in 1854 to the recent work of Marconi and Lodge. It contains references to various patents and other sources of information, and is an extension of S. P. Thompson's review of the subject in April, 1898, in the Journal of the Society of Arts. R. A.

1110. *Electrostatic and Magnetic Causes of Cross Talk.* **K. B. Miller.** (Amer. Electn. 11. pp. 28–29, 1899.)—The author shows, with diagrams, the effect of crossing the lines of metallic circuits. M. O'G.

SCIENCE ABSTRACTS.

PHYSICS AND ELECTRICAL ENGINEERING.

AUGUST 1899.

GENERAL PHYSICS.

1111. *Viscosity of Supercooled Liquids.* **G. Tammann.** (Zeitschr. Phys. Chem. 28. pp. 17–32, 1899.)—The author determines the viscosities of supercooled grape sugar, cane sugar, brucine, piperine, papaverine, and other organic substances. In the neighbourhood of the freezing-point the viscosity increases at a normal rate; but at an average of 90° (the actual numbers vary considerably) below the respective freezing-points it begins to increase at a very rapid rate. In the case of betol, experiment shows that there is no change in volume corresponding to the remarkably large change in viscosity; presumably the same applies to the other cases. A. Gs.

1112. *Optical Measurement of Length.* **C. Fabry, J. M. de Lépinay,** and **A. Perot.** (Comptes Rendus, 128. pp. 1317–1319, 1899.)—The solid to be measured is placed between two planes of silvered glass, A′ A′, so that the faces a, a' of the solid are parallel to the planes. Then the thickness of air between A and A′ is the sum of the thickness of the solid and of the two layers of air aA and a'A′ contained between the solid and the glass planes. The upper part of the space between A and A′ is free, and can be measured by an interference method already described. The small intervals aA and aA′ are also measured by interference fringes with the aid of test plates and strong monochromatic rays derived from a mercury arc. The main condition of accuracy, viz., the perfect parallelism between the silvered planes, is easily verified by the appearance of the fringes. The whole of the adjustment and measurement may be accomplished in a few seconds, so that fluctuations of temperature do not seriously affect them. The results attained are very accurate, the error not exceeding 0·1 μ in a measured length of 4 cm.
E. E. F.

1113. *Measurement of Liquid Volumes.* **J. Wagner.** (Zeitschr. Phys. Chem. 28. pp. 193–219, 1899.)—A minute investigation of the sources of error attending the measurement of liquids and the use of standard solutions. The degree of accuracy attainable with pipettes, measuring flasks, and burettes is considered with reference to the mode of emptying, the time of outflow, changes in temperature, errors of graduations, &c. Errors in weighing and the reduction of weighings to a vacuum are also dealt with. Stress is laid on the necessity of removing all dirt and grease from the surface of measuring vessels if exact results are to be obtained; a mixture of concentrated sulphuric acid with potassium bichromate is one of the best cleansing agents. The delivery of pipettes is in general best completed by blowing out the last portions of liquid. The amount of liquid left adhering to the walls of the pipette varies with different liquids, but in the case of ordinary aqueous solutions these differences may safely be neglected. When using measuring flasks the portion of the neck above the liquid should be carefully dried, and the final adjustment to the mark effected by means of a capillary pipette. Burettes may be read to within 0·01 cc., but the errors of graduation, even with the best instruments, are almost always such as to necessitate careful calibration and the construction of a table of corrections. At least 40–45 seconds should be allowed to elapse before the burette is read, so as to allow of the draining of the liquid down the sides of the tube. Neglect of alterations in temperature may lead to considerable errors, since a change from 15° to 25° increases the volume, and diminishes the concentration, of ordinary normal solutions to the extent of 0·2–0·3 per cent. A table of corrections for temperature is given. It is suggested that a temperature of 20° would be much more generally useful and convenient than 15° as a standard temperature for the graduation and verification of graduated vessels. The importance of purity in the reagents used in preparing solutions is insisted on, and illustrations are given of the small value to be attached to the usual commercial guarantees of purity. N. L.

1114. *Instrument-Reading.* **F. G. Baum.** (Phys. Rev. 8. pp. 181–183, 1899.)—The paper gives a mathematical account of a general method for determining the best reading of an instrument for least error in measuring a given quantity. If y is the quantity to be measured, and x the observed quantity, and if y equals $f(x)$, then the best reading is given by the equation

$$f(x) \cdot f''(x) = [f'(x)]^2$$

A. Gs.

1115. *Aneroid Barometers.* **C. Chree.** (Phil. Trans. 191. pp. 441–499, 1898.)—The paper contains accounts of careful

experiments with aneroid barometers. The author studied the elastic after-effect, the effects of temperature, secular changes, &c. Curves and empirical formulæ generalise the results attained

A. Gs.

1116. *Stroboscopic Determination of Speed, Frequency, and Lag.* **G. Benischke.** (Elektrotechn. Ztschr. 20. pp. 142–147, 1899.)—The speed of fan motors is determined by means of another motor, the shaft of which carries a counting mechanism and a stroboscopic disc, through which the fan is viewed.

To determine frequencies, the current whose frequency is to be determined is passed through an electromagnet, and the field of this magnet is allowed to act on an iron rod supporting a flask of water having a tap from which a thin stream can flow. The alternating magnetic field causes the iron rod to vibrate, and the stream of water to be broken up into a series of drops corresponding in number to the alternations. The number falling in unit time can be determined stroboscopically by means of a rotating slotted disc.

To determine lag, the light from an alternate current arc (which fluctuates with the alternations) is observed through a rotating slotted disc driven by an alternate current motor supplied by the same current as the arc. If the motor runs synchronously the disc appears to stand still; if there is a lag, the image will rotate, and the number of spokes passing a given point per minute will give the number of revolutions by which the motor falls below the speed of synchronism.

C. K. F.

1117. *Harmonic Motion.* **C. Barus.** (Science, 9. pp. 385–405, 1899.)—After a summary of the requirements of the ideal apparatus to illustrate wave motion under different possible circumstances, the author describes a wave machine he has constructed to fulfil these conditions.

The vertical oscillations of the "particals," which are represented by small balls riding on the ends of horizontal levers, are produced by means of two systems of lifting cams, borne by two axes lying parallel to the direction of propagation. In this way composition of waves may be introduced. A limb attached at right angles to each lever can, when desired, by pressing on one set of cams, introduce a horizontal component in the oscillations. Provision is made for inserting various systems of cams of different successive angular displacements, as well as for different relative rates of revolution of the axes.

The paper gives full particulars of how, by these simple means, the various kinds of wave propagation may be illustrated.

F. T. T.

1118. *Period and Logarithmic Decrement of a Continuously Vibrating Wire.* **J. O. Thompson.** (Phys. Rev. 8. pp. 141–151, 1899.)—Experiments performed at Glasgow in 1864–5 made it appear probable that a wire kept for a long time in constant torsional vibration exhibited an increased period and an increased logarithmic decrement. The present paper describes elaborate experiments undertaken to test this conclusion. The torsional pendulum was arranged in a basement chamber, whose temperature suffered a change of only about half a degree in the twenty-four hours. The amplitude was maintained constant by an automatic electromagnetic arrangement when testing the constancy of the period.

The wire was of copper, 37·7 cm. long. and 0·081 cm. in diameter. The arc was 180°. The figures for the period incline the author to the belief that the period changes with the temperature, not instantly, but in a somewhat sluggish manner. In one experiment with a copper wire the period, after fifty hours of continuous vibration through an average arc of 180°, was found to be just what it was in the first two minutes. Gauss's method of timing was used, and the degree of accuracy aimed at and attained was about $\frac{1}{20000}$. To test the logarithmic decrement, two silvered mirrors were mounted back to back, so that their edges were towards the scale when the pendulum was at rest. A double amplitude of vibration of about 180° was then used, so as to give, at each turning-point, readings near the centre of the scale. The total arc was allowed to fall from about 185° to 175°. The electrical driving device was then used to bring the amplitude up to its original value. In keeping the wire in continuous vibration through an average arc of 180° for fifty consecutive hours the results show that the logarithmic decrement varied between 0·00370 to 0·00358; the temperature varied through 2·7°.

Other experiments showed that, by suitably modifying the antecedent amplitude of vibration *any decrement within wide limits*, and *any period within narrow limits* might be obtained. The author concludes that in any vibrating wire not unduly loaded, when temperature and amplitude of vibration are constant, both the period and logarithmic decrements are constant quantities. E. H. B.

1119. *Continuity of Wave Motion.* **Kelvin.** (Phil. Mag. 46. pp. 494–500, 1898.)—Imagine a rigid globe of platinum 12 cm. in diameter hung inside a rigid massless spherical shell of 13 cm. internal diameter. Let the shell and nucleus be made to oscillate in opposite directions with simple harmonic motion. Then, in air, we have, for suitable frequencies, a range of audible sounds; by increasing the frequency we get homogeneous polarised light. If the apparatus is imbedded in an elastic solid, and made to vibrate as before, then for moderate frequencies (10^6 or even higher) two sets of waves are propagated with

different velocities, each independent of the frequency. Raising the frequency to values corresponding to radiant heat, visible light, or ultra-violet light, the question is, what becomes of the condensational-rarefactional waves, and what is the nature of the transition of the velocity of propagation of the distortional waves from 3 kilom. per second to 200,000 kilom. per second (the medium being glass)? "Is it probable (if ether is absolutely incompressible it is certainly possible) that the condensational-rarefactional wave becomes less and less with frequencies of from 10^6 to 4×10^{12}, and that there is absolutely none of it for periodic disturbances of frequencies from 4×10^{12} to 3000×10^{12}?"

Again, let the shell be deeply imbedded in, and firmly attached to, a very large homogeneous elastic solid, and let the shell and nucleus make rotational oscillations (in virtue of a mutual forcive) about a common axis. Purely distortional waves will be propagated. For a small frequency, at distances of hundreds of kilometres, the wave-length will be (in glass or iron) approximately 3 kilometres; for frequency 1000 it will be about 3 metres at distances of hundreds of metres; for frequency 10^6 it will be 3 millim. throughout the medium, except close to the shell. For a frequency such as 100×10^{12} "it is probable that no distortional wave of motion of the ponderable matter can be transmitted outwards; but it seems quite certain that distortional waves of radiant heat in ether will be produced close to the boundary of the shell, although it is also probable that if the surrounding solid is either glass or iron, these waves will not be transmitted far outwards, but will be absorbed, that is to say converted into non-undulatory thermal motions, within a few mikroms of their origin."

To obtain an electrical analogy the shell must be replaced by a rigid, infinitely massive shell of glass or other non-conductor, and the nucleus by a massless non-conducting globe electrified with a given quantity of electricity. The apparatus being supposed surrounded by air or ether, vibrations to and fro with moderate frequencies give a periodic variation of electrostatic force in the medium, the phase nearly agreeing with that of the vibrator. High frequencies (such as 100×10^{12}) give polarised light. Rotational oscillations, for moderate frequencies, give no alteration of the electrostatic force and no perceptible magnetic force: high frequencies will give polarised light. "The same result would be obtained by taking simply a fixed solid non-conducting globe and laying on wire on its surface approximately along the circumferences of equidistant circles of latitude, and, by the use of a distant source, sending an alternate current through this wire. In this case, while there is no manifestation of electrostatic force, there is strong alternating magnetic force, which in the space outside the globe is as if from an ideal infinitesimal magnet with alternating magnetisation, placed at the centre of the globe and with its magnetic axis in our axial line." G. B. M

1120. *Production of Waves in an Elastic Solid.* **Kelvin.** (Phil. Mag. 47. pp. 480–493, 1899.)—The author considers the application of the force within a limited space required to produce spherical solitary waves, or trains of periodic waves, of both species, equivoluminal and irrotational. By equivoluminal it is understood that every part of the solid keeps its volume unchanged during the motion. Referring to Stokes' paper on the Dynamical Theory of Diffraction (Stokes' Mathematical Papers, vol. 2, p. 243) he gives the equation of motion, as in his former papers, in terms of ξ, η, ζ, the displacements at any point in the solid, and gives an answer to the question as to what the forcive must be, applied to the boundary of a hollow S of any shape in the solid, when the strain of the matter in contact with S′ is given. Then he confines himself to the case in which S is spherical, and the motions and forces are in meridional planes through a diameter OX.

He finds the complete solution of the equations of motion in the form $\xi=\xi_1+\xi_2$, &c., in which ξ_1 belongs to the equivoluminal wave propagated with velocity u, and ξ_2 to the irrotational wave with velocity v, each wave being capable of existing without the other. Hence he finds the most general irrotational solution and the most general equivoluminal solution, and discusses the general result. S. H. B.

1121. *Transformation of Central Motions.* **P. Stäckel.** (Göttingen Nachrichten, 2. pp. 157–165, 1898.)—(1) The author describes Boltzmann's transformation. Boltzmann had shown that if a particle describes a curve under a central force $f(r)$, with k for area constant, *i.e.*, the area described in unit time by the radius vector r, then another particle under a force $f_1(r)$ may describe a curve in which r is the same function of the time as in the former case, with k_1 for area constant, provided that

$$f_1(r)-f(r)=\frac{k^2-k_1^2}{r^3}.$$

(2) The author then considers the case of a particle moving on a surface of revolution under a force directed towards the axis, and he shows that Boltzmann's transformation is a particular case of this problem.

(3) Finally he discusses the general problem of transformation of motions, considering the curves which belong respectively to two related "Mannigfaltigkeiten" M_n and m_n. S. H. B.

1122. *Deformation and Sliding in Calcareous Spar.* **W. Voigt.** (Göttingen Nachrichten, 2. pp. 146–153, 1898.)—The author discusses experiments in which a rectangular parallelopiped of calcareous spar, suitably orientated with respect to the crystallo-

graphic axis, was subjected to gradually increasing pressures until sliding commenced between the layers. He draws the conclusion that the sliding depends not, or not only, on the geometrical configuration of the sliding layer, but on a process which goes on within the molecules of the substance. This theory he would extend to all deformations which take place in solid bodies—and he considers that a theory of elasticity founded on the assumption of the molecules being rigid or unchangeable bodies can be no more than an approximation. Also he regards this as an argument in favour of his own view. (Gött. Nachrichten, 1893, No. 16, p. 669) of the nature of Piëzo-electricity and Thermo-electricity.
S. H. B.

1123. *Exploring-Balloons.* **A. Bouquet de la Grye.** (Ann. du Bureau des Longitudes A1–A14, 1899.)—An interesting *résumé*. Greatest height attained, 18,450 metres, Tempelhof military balloon park; temperature observed, – 68° C. Greatest theoretical height for practicable balloon, with instruments, about 20,000 metres, or about 23,000 metres in sunshine. Greatest height reached by aeronaut (inhaling oxygen), M. Berson, 9,156 metres. It is of advantage not to fill the balloon completely before it is launched, but to allow for expansion under the diminished pressure above. The height attained can be regulated by supplementary weights. The drift at high altitudes is generally towards the N.E., whatever the wind below. At 15,000 metres there is a difference of 50° C. between the sunshine and the shade. Kites at 4,000 metres provide controls for the instrumental observations. Altitudes may also be measured by the angle of view on photographic plates. A. D.

1124. *Modern Geodesy in France.* **Bassot.** (Ann. du Bureau des Longitudes, B1–B34, 1899.)—A very interesting summary of the work done in revising the triangulation and connecting the surveys of France, Spain, and Algeria, and of the work to be done for the new map of France and the survey of the French colonies. Subsidiary work in measuring the local force of gravity is also described. A. D.

1125. *Gravity on Mont Blanc.* **P. Pizzetti.** (Roma R. Accad. Lincei Atti, 8 pp. 34–38 and 65–68, 1899.)—A mathematical paper. The attraction of Mont Blanc, after allowing for snow and ice, is less than the calculated value by an amount corresponding to an ideal indefinite horizontal cavity of about 1,000 metres in height: 250 metres, apparently, from measurements at Chamounix. A. D.

1126. *Meteorological Observations at Göttingen.* **J. Kümmell.** (Göttingen Nachrichten, 3. pp. 223–259, 1898.)—The paper is compiled on the plan of the climate of Frankfurt-on-the-Main by J. Ziegler and W. König and covers the period 1887 to 1896, Hugo Meyer having already published statistics on the years 1857 to 1881. The data for 1881 to 1887 were incomplete. Göttingen is a second-class meteorological observatory, situated 150 m. above sea-level, in lat. 51° 32′ and long. 9° 56′ E. When the barometric means observed, 747·8 mm. annual, 749·6 for January, 747·0 for July are reduced, the figures remain 1·0 mm. (annual mean), or 2·4 mm. (January) higher than those corresponding to Ferrel's averages for that latitude. Some of the extremes are striking (768·6 mm. on January 29, 1896, and 719·8 on February 9, 1889, and the sharp fall in the barometric curve in March; the falls in September and in June are less marked). Owing to the prevalence of S.W. winds and the (local) protection against E. winds, the temperature is higher than the average for that latitude by 9° according to Hann, by 4·6° according to Spitaler. On the other hand, the period 1887 to 1896 has been cooler (annual difference 0·3, January 1, 1·7) than the period 1857 to 1881. This applies also to Bremen and Frankfurt-on-the-Main, and probably to Central Europe in general; the absolute humidity curves of the two periods show the same relations. Attention is drawn to pentades, periods of five days, to temperature relapses, and to the apex values of the various months. As regards rain, the popular rule seems to hold that a low barometer signifies rainy weather. H. B.

LIGHT.

1127. *Methven Standard with Blackened Chimney.* **R. A. Fessenden.** (Elect. World, 33. p. 231, 1899.)—The author points out the error produced by blackening the back of the chimney round the standard flame. The argument in favour of blackening the back of the chimney is as follows: A certain amount of light is reflected from the back of the chimney and thrown forward through the Methven slot, thus making more light pass through the slot. It is, however, obvious that if the back of the chimney throws by reflection extra light through the slot, the same amount is thrown away from the slot by the reflection of the front of the chimney, so that the presence of a glass chimney, if symmetrical round the flame, does not increase the amount of light passing through the slot. As a matter of fact it slightly reduces it, for two reasons: first, on account of the absorption of the glass; second, because some of the reflected light is thrown out at the ends of the chimney.

E. C. R.

1128. *Candle-Power of Glow Lamps.* **R. A. Fessenden.** (Elect. World, 33. p. 230, 1899.)—The author measures the mean horizontal candle-power and divides it by the mean spherical candle-power: this ratio, expressed as a percentage, he calls the distribution factor. This varies from 72 to 84 in a number of experiments made. In general, the longer the filament of a given type of lamp the greater the distribution factor. In other words, a comparatively low resistance carbon should be used where uniform distribution is wished. Also, contrary to what was expected, there is practically little difference between horseshoe and looped filaments, as met with in the market, so far as distribution is concerned, the average factor being 76 for looped filaments $8\frac{1}{2}$ inches long, and 78 for horseshoe filaments 6 inches long. E. C. R.

1129. *Light at Low Temperatures.* **A.** and **L. Lumière.** (Comptes Rendus, 128. pp. 359–361, 1899.)—Ultra-sensitive gelatino-bromide photo-plates, cooled to $-191°$ C. (liquid air), require from 350 to 400 times as long an exposure to light to produce a given effect as is required at ordinary temperatures: most of the sensitive photographic preparations are not acted upon at all. The plates are not permanently altered at all by the cooling, neither is any latent image, existing within their film. The cooling is the only cause of the temporary deprivation of sensitiveness; and the production of the latent image

appears to be due to chemical action. Substances made to phosphoresce by light have their phosphorescence extinguished by immersion in liquid air, to be fully regained as the temperature is restored. A. D.

1130. *Singular Points in Optical Systems.* **P. Lefevre.** (Comptes Rendus, 128. pp. 1320–1322, 1899.)—There are several interesting relations between the "poles" of an optical system as defined by the author and Bravais' points. For instance: a circumference or straight line passing through Bravais' points, and another circumference or straight line passing through two poles and situated in the same plane, intersect at right angles. Also: the distance of any point on the axis from the line joining the poles is the arithmetic mean of its distances from Bravais' points. The relations discovered may be immediately applied to thick lenses and mirrors. E. E. F.

1131. *Paris Exhibition Siderostat.* **P. Gautier.** (Ann. du Bureau des Longitudes, C1–C26, 1899.)—An account of this instrument, with drawings and details as to manufacture, particularly of the mirror. The focal length is 60 metres and the aperture of the objective 125 cm. The arrangement renders the ocular part independent of the apparent movement of the sky, enables stars to be either observed or photographed, and provides the ocular with movements in right ascension and declination. The mirror is 2 metres in diameter. A. D.

1132. *Apparent Colour.* **W. B. Lane.** (Canad. Instit. Trans. 5. pp. 225–241, 1898.)—This is a preliminary paper in which the author deals with the modifications produced in the apparent colour of objects by change of the observer's distance. Previous work on this subject is referred to, and the author leaves over for a future paper an account of his later observations with more accurate apparatus. Some of the results obtained appear to contradict Hering's theory of colour. J. J. S.

1133. *Transmission of Light by Turbid Media.* **P. Compan.** (Comptes Rendus, 128. pp. 1226–1229, 1899.)—If a radiation of intensity I_0 traverses a turbid medium of thickness z, its intensity I after transmission is given by the formula

$$I = I_0 e^{-kz}$$

According to Clausius, $k = m/\lambda^2$, where λ is the wave-length and m a constant. According to Stokes, $k = m/\lambda^4$.

The author has experimented upon lampblack, silver chloride, magnesia, barium sulphate, and other bodies to discriminate between these formulæ. He finds that neither of them strictly applies, and that the transmission depends upon an additional factor, viz., the size of the disturbing molecule. E. E. F.

1134. *Total Reflection.* **E. Ketteler.** (Wied. Annalen, 67. 4. pp. 879–893, 1899.)—The "glancing ray" which, according to Voigt, penetrates into the second medium in so-called total reflection must, according to the author, be explained on principles different from those given. The author shows that if the media are transparent, the energy of the "glancing ray" per unit of time is zero, and therefore the totally reflected ray has the same energy as the incident ray. During half the time the momentary energy of the incident wave exceeds that of the reflected wave, and energy is transferred to the ether of the second medium. But during the other half of the time the same amount of energy is withdrawn again. The net result is that though there is a wave motion at the boundary of the two media, no train of waves is propagated into the second medium. The equations for absorbing media are of the same form, and the conclusion is similar.

The author proceeds to work out simplified equations for absorbing media, and applies them to the theory of metallic reflection. E. E. F.

1135. *Optical Characteristics of Garnet.* **C. Klein.** (Berlin Akad. Sitzber. 44. pp. 676–692, 1898.)—A mineralogical paper, in which the investigations of the author as well as those of other observers into the optical anomalies of the various forms of garnet are considered. J. J. S.

1136. *Refractive Indices of Chloride Solutions.* **J. Conroy.** (Roy. Soc. Proc. 64. pp. 308–318, 1899.)—An account is given of observations of the refractive indices and densities of normal and semi-normal aqueous solutions of hydrogen chloride and the chlorides of the alkalis at a uniform temperature of 18°. The results are set forth in a table in which the indices are given to six places of decimals and the densities to five places. A second table gives the results corrected for small errors in the strengths of the solutions. It appears that both the densities and the refractive indices increase with the molecular weight of the substance in solution, except in the case of the refractive index of potassium chloride, which is slightly lower than that of sodium chloride. In other tables are given the weight of water contained in 1000 cc. of each of the solutions, and the differences between

the refractive indices of the solutions and the refractive index of water under ordinary conditions.

The method employed was the ordinary hollow prism one, special care being taken to keep the solution at 18°, or within one- or two-tenths of a degree of 18°. An alteration of 1° in the temperature of water at about 20° makes a difference in the refractive index of nearly one unit in the fourth decimal place.

J. J. S.

1137. *Theory of the Microscope.* **K. Strehl.** (Zeitschr. Instrumentenk. 18. pp. 301–317, 1898.)—Referring to Abbe's papers on this subject, and also to the recent ones of Rayleigh and Wright, the author enters into various calculations with reference to the formation of images in the microscope. He includes in his discussion chromatic aberration, astigmatism, and spherical aberration, basing his work chiefly on the formulæ for the theory of the telescope. J. J. S.

1138. *Constant of Emission Function Photometrically Determined.* **F. Paschen** and **H. Wanner.** (Berlin Akad. Sitzber. 2. pp. 5–11, 1899.)—According to the theory of W. Wien the radiation intensity of an "absolutely black body" has the form

$$J = c_1 \lambda^{-5} e^{-c_2/\lambda T} \qquad (1)$$

where J is the intensity of radiation of wave-length λ at the absolute temperature T. The truth of this expression was rendered probable by experiments by Paschen, and the object of the present work was to determine c_2. Equation (1) may be put in the form

$$\log_{10} J = r_1 - r_2/T, \qquad (2)$$

where

$$r_1 = \log_{10} (c_1 \lambda^{-5}),$$

and

$$r_2 = \frac{c_2}{\lambda} \log_{10} e.$$

A curve, called the *Isochromatic Line*, may then be plotted, having values of 1/T as abscissæ and the corresponding values of $\log_{10} J$ as ordinates. The slope of this line gives r_2, and thus c_2 as required.

The experimental determination was carried out by means of a König's Spectro-Photometer. As the best approach to an "absolutely black body," a surface blackened with iron oxide was used. Tables of results for four different wave-lengths and for various temperatures are given. The Isochromatic Lines

are plotted for three of these wave-lengths, and are, in each case, straight lines. The values found for c_2 are as follows :—

	μ	μ	μ	μ
$\lambda =$	0·6678	0·5893	0·5016	0·4861
c_2	14322	14489	14467	14473

Mean value of $c_2 = 14440$ [$\mu \times$ absolute temperature].

E. H. B.

1139. *Magneto-Optic Phenomena.* **J. G. Leathem.** (Cambridge Phil. Soc. Trans. 17. pp. 16–40, 1898.)—Leathem refers to Fitzgerald's investigations on the electromagnetic theory of the reflexion and refraction of light (Phil. Trans. 1880), and to Larmor's modification of them in his report on the action of magnetism on light (Brit. Assoc. 1893). Larmor introduces into the equations as given by Fitzgerald the Lagrangian indeterminate multiplier λ, which satisfies the condition $\nabla^2\lambda = 0$, and so appears as the potential of a distribution over the interface of two media, at which reflexion takes place. It may be interpreted as an irrotational or pressural wave propagated along the interface. In the present paper Leathem uses the Principle of Least Action and introduces a Dissipation Function to obtain from the above hypothesis the equations of propagation in a conducting medium and the boundary conditions at an interface of two such media. These are applied to the solution of the problem of reflexion of light from a magnet and the results compared with experiments of Kerr, Sissingh, and Zeeman. Leathem arrives at the conclusion that the theory considered does not satisfactorily explain the observed facts. S. H. B.

1140. *Magneto-Optic Theory.* **W. Voigt.** (Wied. Annalen, 67. 2. pp. 345–365, 1899.)—The author attempts to frame a complete theory of the magneto-optic effects by amplifying the equations governing selective absorption. It is based upon Drude's Hertzian equations. He succeeds in explaining some apparent anomalies, and his formulæ are corroborated by the results recently obtained by Becquerel. E. E. F.

1141. *Rotatory Polarisation of Malic Acid.* **L. Kann.** (Wien Akad. Sitzber. 107. pp. 681–705, 1898.)—A record is given of an extensive set of observations on the rotatory polarisation exhibited by solutions of malic acid of various concentrations. The measurements were made with a Lippich's half-shadow polarimeter and the temperature varied from about 10° to 100° C. The results obtained are embodied in fourteen tables, and the effect of change of temperature is clearly shown in the curves given by the author, which also indicate the anomalous dispersion which occurs with certain concentrations and temperatures. J. J. S.

1142. *Magnetic Polarisation of Quartz.* **A. Borel.** (Comptes Rendus, 128. pp. 1095–1097, 1899.)—The magnetic rotatory polarisation of quartz, discovered by Becquerel, is difficult to study, on account of the natural rotational power which that mineral possesses without any magnetic field. The author has, however, succeeded, by employing a combination of right-handed and left-handed quartzes, 6 cm. thick, which, together, produce no optical rotation. He studied the rotation of a few lines, chiefly cadmium lines, which extend from the red far into the ultra-violet. He used the ordinary polarimeters of Laurent, Summer, and Wild, but for the ultra-violet measurements he employed the fluorescent eye-piece devised by Soret. He thus determined Verdet's constant for eight spectrum lines. This constant increases with the refrangibility of the rays. It is 0·01684 for the D line of sodium and 0·16032 for the 25th (ultra-violet) cadmium line, whose wave-length is 319·39 $\mu\mu$. The rotation increases with the temperature, at a rate which increases with the refrangibility. E. E. F.

1143. *Spectra.* **A Pérot** and **C. Fabry.** (Comptes Rendus, 128. pp. 1221–1223, 1899.)—The number and intensity of lines in electric spark spectra depends largely upon the manner of excitation of the vacuum tube. No direct influence of the excitation upon the wave-length of the lines has hitherto been observed, but often an apparent displacement occurs due to the emphasising of a certain portion of a group of lines in close proximity at the expense of another portion. For various physical purposes it is important to have spectrum lines as bright and as sharply defined as possible. The authors have determined the conditions most suitable for these requirements. The best results were obtained by inserting the tube in a continuous-current circuit having a difference of potential of at least 700 to 800 volts. This was done by means of a battery of 500 small accumulators of 0·4 ampere-hour capacity. Such a battery is capable of maintaining the tube in action for a very long time, since the current required by the tube is not more than 3 or 4 milli-amperes. The rays attained are of extreme fineness. Thus the coincidence of the fringes furnished by the green and the red rays of cadmium could still be observed with a difference of path amounting to 18 cm., which permits the optical measurement of thicknesses up to 9 cm. E. E. F.

1144. *Chemical Action of Röntgen Rays.* **P. Villard.** (Comptes Rendus, 128. pp. 237–239, 1899.)—Gelatino-bromide photo-plates fully acted upon by Röntgen rays are regenerated by light, say a large Welsbach burner at 40 cm. for 50 seconds, with the exception that the plate is no longer sensitive to light. The region of the spectrum most active in this sense is precisely that

which acts most powerfully upon the photo-plate, being most absorbed by it; but there are also other regions of maximum activity in minor degree, which vary with the plates made use of. After being subjected to Röntgen rays the plates become in this way sensitive to the reversing effect of rays of such low refrangibility that they can pass through three thicknesses of black paper, and a positive of that part of the spectrum is produced. If sufficient time of exposure be allowed, the reversing effect is visible without development of the plate. A Röntgenised photo-plate given a long exposure in the camera (30 secs.) gives on development a positive image of the object. A. D.

1145. *Fluorescent Solid Solutions.* **J. R. Mourelo.** (Comptes Rendus, 128. pp. 1239–1241, 1899.)—The author has experimented with a variety of solid solutions of manganese carbonate in strontium sulphide in order to determine the composition giving the greatest intensity of fluorescence. The best results were obtained with a mixture of strontium carbonate 100 grammes, flowers of sulphur 33 gr., sodium carbonate 1·4 gr., fused sodium chloride 0·85 gr., manganese carbonate 0·15 gr. This mixture was finely powdered, compressed, and placed in an earthenware crucible. It was kept at a red heat for three hours, and was then allowed to cool slowly. The result was a hard, compact, greyish-white mass of scoriated appearance. Exposed to daylight, it showed a brilliant green fluorescence. The colour is brighter and purer than that obtained with bismuth nitrate in the place of manganese carbonate. A good fluorescence may also be obtained by heating together 100 parts strontium carbonate, 33 parts flowers of sulphur, and 0·15 part manganese carbonate. After a few seconds of exposure to daylight it shows a fine and persistent green fluorescence, without blue or yellow light. It is possible that other fluorescent substances may be prepared in a similar manner, and in this connection it must be remembered that Boisbaudran obtained fluorescence of various solid solutions of manganese sulphate by exposing them to an electric brush discharge. E. E. F.

HEAT.

1146. *Thermal-Conductivity of Liquids.* **E. van Aubel.** (Zeitschr. Phys. Chem. 28. pp. 336–341, 1899.)—Lees' results are tabulated against those of H. F. Weber and Graetz, and the want of agreement, especially as regards the variation with temperature, is pointed out. Weber's law, that the diffusivity of a liquid per unit density, or $k/c\rho$, is inversely proportional to the mean distance between its molecules, or $\sqrt[3]{(m\ \rho)}$, is then examined and found to be wanting. R. E. B.

1147. *Pressure and Thermal Conductivity.* **C. H. Lees.** (Mem. Manchester Lit. and Phil. Soc. 43. 8. pp. 1–6, 1899.)—Slices of substances from $\frac{1}{5}$ to 2 cm. thick were submitted to pressures up to $54\frac{1}{2}$ atmospheres, being squeezed in a hydraulic press between steel discs, one of which was uniformly heated by electrical means and the other cooled by a continuous flow of water. Contact between the discs and slices was ensured by layers of glycerine. No change of conductivity with pressure was found within the experimental limits in the cases of granite and marble, but a slight increase in the cases of glass and ebonite and an increase of 4 or 5 per cent. in the case of soft sandstone were observed. The experiments are to be repeated with mercury substituted for glycerine. R. E. B.

1148. *Measurement of Thermal Conductivity.* **C. H. Lees.** (Phil. Trans. 191. pp. 399–440, 1898.)—The materials to be tested in the case of solids are cut into discs of 4 cm. diameter and of various thicknesses. On one side of the disc to be tested is placed a copper disc of the same diameter and on the other side a compound disc, consisting of two copper discs enclosing between them a flat heating coil of silk-covered platinoid wire, also of the same diameter. At opposite extremities of a diameter of each copper disc are bored radial holes, into which are respectively soldered a platinoid and copper wire to form a thermojunction. The whole is enclosed in an air bath which can be kept at any required temperature by a coil of insulated platinoid wire wound outside it. The temperature differences between the discs are measured by balancing the E.M.F. of the thermojunctions against a known potential difference on a potentiometer.

In the case of liquids the arrangement is somewhat modified.

The paper gives full descriptions of the apparatus, and precautions employed, theory of the methods, and the results of experiments with a number of solids, liquids, and mixtures of liquids which are thus summarised :—

1. Solids which are not very good conductors of heat, in general decrease in conductivity with increase of temperature in the neighbourhood of 40° C. Glass is an exception to this rule.

2. Liquids in the neighbourhood of 30° C. follow the same law.

3. The conductivity of a substance does not invariably change abruptly at the melting-point.

4. The thermal conductivity of a mixture lies between the conductivities of its constituents, and seems to be connected with the constitution and conductivities by a simple law.

5. Mixtures of liquids decrease in conductivity with increase of temperature in the neighbourhood of 30° C. at about the same rate as their constituents. E. C. R.

1149. *Specific Heat of Liquids.* **D. Negreano.** (Comptes Rendus, 128. pp. 875–876, 1899.)—The author describes a rapid method of comparing the specific heats of two liquids by heating up equal volumes in a test-tube by a coil carrying an electric current. E. E. F.

1150. *Heat of Fusion.* **G. Tammann.** (Wied. Annalen, 67. 4. pp. 871–878, 1899.)—The author investigates the dependence of the heat of fusion upon temperature and pressure, in order to decide the question as to the existence of a critical state between solid and liquid. For that to be the case, it is necessary that the specific volumes of the body in the two states become equal, and that at the same time the difference of energy of the unit mass becomes zero. The author does not acknowledge that this has yet been proved in a single instance. An apparently continuous transition from the crystallised to the liquid state is only observed when the conditions are unfavourable for seeing the dividing surface. E. E. F.

1151. *Temperature Regulator.* **E. Gumlich.** (Zeitschr. Instrumentenk, 18. pp. 317–320, 1898.)—A description of a temperature measurer based on the principle of the Metal-thermometer. Two strips of metals with expansion coefficients which differ as much as possible, *e.g.*, nickel and brass, are joined together throughout their length and bent into a spiral, one end of which is fixed and the other controls a pointer which moves over a large dial. A change in temperature of 100° in one case produced a movement of the pointer of over 360°. The details of the arrangement are best shown by the perspective sketch given in the paper. J. J. S.

1152. *Expansion of Ice.* **E. L. Nichols.** (Phys. Rev. 8. pp. 184–186, 1899.)—In view of the conflicting results obtained by Petzholdt, Brunner, Struve, Marchand, and Plücker and Geissler with regard to the thermal expansion of ice, the author has utilised a spell of exceptionally cold weather at Ithaca to make some further measurements. These were made on bars of artificial ice 45 cm. long, and the open-air temperature fluctuated between $-3°$ and $-17°$. The marks observed in the microscopes were the rims of small drops of mercury lying in hollow cavities in the ice. The coefficient obtained was 54×10^{-6}, which agrees best with Struve's value. E. E. F.

1153. *Compressibility of Gaseous Mixtures.* **D. Berthelot.** (Comptes Rendus, 128. pp. 1229–1231, 1899.)—The compressibility of a mixture of two gases may be calculated from that of its components. The compressibility of a mixture of x molecules of one gas with $1-x$ of another is represented, like that of the gases separately, by the formula of Van der Vaals. The co-volume B of the mixture equals the mean of the co-volumes b and b' of the constituents :—

$$B=bx+b'(1-x).$$

The specific molecular attraction A is obtained by admitting that, if the mutual attraction of two molecules of the first gas is proportional to a and that of two volumes of the second gas proportional to a', the attraction between two molecules of different gases is proportional to $\sqrt{aa'}$, so that

$$A=ax^2+2\sqrt{aa'}\,x(1-x)+a'(1-x)^2.$$

The constants a and b have the following values for the gases mentioned :—

	H	N	CO_2	SO_2
a	0·00050	0·00105	0·00913	0·02840
b	0·00114	0·00067	0·00243	0·00535

The observed increase of pressure on mixing various gases is 3·9 mm. for SO_2+H_2, 1·4 mm. for SO_2+CO_2, 1·0 mm. for CO_2+H_2, and 0·2 mm. for H_2+O_2.

The calculation of the compressibility of a gaseous mixture is quite feasible, but only within the limits of the applicability of Van der Waals' equation. E. E. F.

ELECTRICITY.

1154. *Expressions of Maxwell and Hertz for Magnetic Energy.* **H. Poincaré.** (Écl. Électr. 18. pp. 361–367, 1899.)—In this paper the author begins by setting out Hertz's expression for $\frac{da}{dt}$, where a is the x component of magnetic force, with the corresponding expression given by Maxwell for $\frac{da}{dt}$, where a is the component of magnetic induction. Hertz's formula is expressed in Maxwell's notation. He states that "magnetic induction" is not used in the same sense by the two writers. With Hertz its components are μa, &c. With Maxwell they are $a + 4\pi A$, &c.; and the two expressions are identical only if there be no permanent magnetisation. He then compares the expression given by the two writers for the magnetic energy. Maxwell, he says, gives two, viz., $\frac{1}{2}\int(Aa + \&c.)d\tau$, applicable when there is only permanent magnetisation, and $\frac{1}{8\pi}\int(aa + \&c.)d\tau$, applicable when there is no permanent magnetisation. Hertz gives—

$$\frac{1}{8\pi}\int \mu(\alpha^2 + \beta^2 + \gamma^2)d\tau,$$

with a corresponding expression for the electric energy. Poincaré arrives at the result that Hertz's $\frac{d\tau}{dt}$ has the same value whether $\mu = 1$ or not; and that the components of mechanical force are $(\gamma v_0 - \beta w_0 + am)$, &c., whereas Maxwell gives $(cv_0 - bw_0 + am)$, &c. Here u_0, v_0, w_0 are components of total current, and m is the density of magnetisation. He draws the following conclusions, viz.: (1) Hertz's expression for the energy is to be adopted, and not Maxwell's; (2) The like for the mechanical force; (3) The electric energy with K for μ may be treated in the same way. It is assumed that magnetised bodies are capable of displacement without deformation or change of their permanent magnetisation. In the fifth section the author deals with induced magnetisation, following Weber's method. S. H. B.

1155. *Mechanical Theory of Electricity.* **Holzmüller.** (Elekt. Runds. 16. pp. 18–20, 31–33, 46–47, 1898.)—In these articles the author summarises a few of the general results of modern views concerning the mechanical theory of electricity. R. A.

1156. *Conduction of Electricity in Gases.* **J. J. Thomson.** (Phil. Mag. 47. pp. 253–268, 1899.)—The electrical conductivity possessed by gases under certain circumstances is regarded as due to the presence in the gas of charged ions, the motion of these ions in the electric field constituting the current. In the present mathematical investigation, account is taken of the production of the ions, the recombination of the ions, and the movement of the ions under the electric forces. It is assumed that the velocity of an ion is proportional to the electric intensity acting upon it. Expressions are then obtained exhibiting the relation between the current and the electric intensity under certain conditions. Curves are also given showing the potential gradient between two charged plates between which charged ions are present.

E. H. B.

1157. *Graphic Representation of Electric Fields.* **E. Bourdréaux.** (Comptes Rendus, 128. pp. 882–883, 1899.)—Attempts to illustrate graphically the course of the lines of electric force, after the fashion of Faraday's magnetic lines, usually fail on account of the attraction, charge, and subsequent repulsion of the electrified metallic powder. The author has, however, succeeded by employing a powdered inferior conductor, sprinkled over a homogeneous and well-insulated non-conducting glass plate. Diamidophenol, crystallised in small needles, answers very well. Cork, elder pith, powdered sugar, and a great variety of other substances may also be employed. The curves are fixed with varnish in the usual way.

E. E. F.

1158. *Instantaneous Polarisation.* **H. Pellat.** (Comptes Rendus, 128. pp. 1218–1220, 1899.)—The author shows that the theory of fictitious or instantaneous polarisation is powerless to explain the forces produced on a non-electrified dielectric placed in an electric field. He supposes a condenser formed of two metallic armatures half immersed in a liquid, and separated by a solid dielectric of the same specific inductive capacity K as the liquid; the solid, however, only reaching to the centre of the armatures, and projecting below into the liquid to such a distance that the field at its edge may be considered as zero. The thickness of the solid dielectric is e, and its breadth l. Air fills up the rest of the space. On establishing a difference of potential between the armatures, the solid dielectric experiences a force—

$$F = \frac{V^2 l(K-1)}{8\pi e}$$

tending to raise it, as may be proved from thermodynamical considerations, and has been experimentally shown by the author. The theory of instantaneous polarisation cannot account

for this force. It is also unable to account for residual charge and other phenomena, as the author showed in his treatise on "Electrostatics not Founded on Coulomb's Law." The author's own theory of persistent polarisation is more successful.

E. E. F.

1159. *Persistent Polarisation.* **H. Pellat.** (Comptes Rendus, 128. pp. 1312–1314, 1899.)—Residual charges may be explained on a hypothesis formulated as follows: A (solid or liquid) dielectric, suddenly placed in an electric field, takes a polarisation which is not instantaneous, but which increases with the time and tends asymptotically towards a maximum. If the field ceases the polarisation decreases, and becomes zero after a time which is theoretically infinite. The truth of this hypothesis is proved by a number of experiments, one of which is the following: A block of ebonite was cut in two and rejoined. The block was then placed between the armatures of a condenser, the armatures being parallel to the cut. After a few minutes' exposure to the field, the latter was reduced to zero, and one of the pieces was inserted between the plates of a smaller condenser connected with an electrometer. The electrometer always indicated a charge, which varied with the face presented to the condenser plates, and gradually diminished. That there was no charge due to conduction was shown by an ice-pail measurement, which failed to show any charge of the piece of ebonite as a whole. E. E. F.

1160. *Volume-Changes of Gases under High E.M.F.* **H. Mache.** (Wien Akad. Sitzber. 107. pp. 708–730, 1898.)—Into the middle of a sphere made of sheet brass was brought a platinum wire pointed at the end and insulated from the sphere. The platinum point was raised to a measured potential by being connected to the pole (+ or −) of a Holtz machine, the other terminal of the machine and also the brass sphere being joined to earth. A gauge, connected to the interior of the sphere, which was in succession filled with different gases (air, hydrogen, and carbonic acid), enabled the change of volume of the gas (whether expansion or compression) to be measured. The following are the results obtained from the experiments:—

1. Gases change their volume if they are exposed to the influence of a strong electric force.

2. This change of volume cannot be explained as due to heating of the gas. It may be either a contraction or an expansion. The former is explained through polarisation, the latter through electrification.

3. If a gas is electrified, its volume increases; or if the volume is kept constant, then the pressure rises. When the electrification is interrupted this effect ceases quickly and completely in con-

sequence of the rapid diffusion of the electrified gases into the surrounding unelectrified space. Its magnitude is dependent on the indicated potential of the electricity.

4. On the discharge of an influence machine or Ruhmkorff through air, a sudden rise of pressure takes place, which instantaneously vanishes if the discharge ceases. This has its origin in the expansion of the electrified air, in connection with the electrically charged metallic vapour. J. J. S.

1161. *Equivalent Resistance and Inductance of Wire to Oscillatory Discharge.* **E. H. Barton.** (Phil. Mag. 47. pp. 433–441, 1899.)—As far back as 1886 Rayleigh deduced expressions for the equivalent resistance and inductance of a wire to alternating currents which follow the simple harmonic law and are of constant amplitude. The present paper considers the case of logarithmically damped harmonic oscillations, and the result arrived at shows that *both resistance and inductance are increased by the damping.* By applying this result to a previous experimental investigation (Abstract 284, 1899), the author finds that somewhat better agreement is obtained with theory than that given by Rayleigh's formulæ for undamped oscillations. A. H.

1162. *Kathode, Lenard, and Röntgen Rays.* **W. Sutherland.** (Phil. Mag. 47. pp. 269–284, 1899.)—J. J. Thomson's hypothesis that the mattter in the kathode stream consists of atoms resolved into particles of that primitive substance out of which atoms have been supposed to be composed, is not an absolutely necessary hypothesis. Thomson and Kaufmann have established that kathode rays travel at the same speed in H_2, air, and CO_2; and that m/e, mass of each particle by the charge it carries, is the same for all gases in kathode discharges, and in hydrogen is about 10^{-3}, the same ratio in ordinary electrolysis. The reasoning is as follows: N particles from the kathode, each of mass m and with velocity v, strike a thermopile and give up their potential energy $\frac{1}{2}Nmv^2 = W$. The total electric charge of the N particles is $Ne = Q$. Whence $\frac{1}{2}v^2 . m/e = W/Q$. But on passing through a magnetic field of strength H, at right angles to the track of the particles, the force tending to deflect each particle is Hev, at right angles to H and v: and each particle describes a circular path of radius ρ with centrifugal force $mv^2/\rho = Hev$; whence $v . m/e = H\rho$. By measuring W, Q and $H\rho$, v and m/e can be found from these equations. Deflection in an electrostatic field leads to similar results. But it is assumed in all this that a charge e must be associated with some mass m. If this is not necessarily so, the charges will travel as free electrons in the ether, say as charges on modified portions of the ether: let us say as spherical shells of

radius a. Certain actions of such a moving electron take place as if it had a localised inertia, so that the whole may have a kinetic energy due to motion: but the term corresponding to m is itself a function of the velocity, except where the velocities are small. In kathode discharges, from this point of view, the electrons which travel are the same in all gases: the gas is like a lubricant, but does not control the discharge; and the stream of electrons will give up its kinetic energy to the thermopile, the energy appearing as heat, for the process is irreversible. When m/e is 10^{-7} (e being measured in electromagnetic units), with Heaviside's relation, kinetic energy of electrons $=\mu e^2 u^2/3a$; also $\mu=1$ and $e=10^{-21}$ in electromagnetic units; the radius a is found to be 10^{-14} cm., as against 10^{-8} cm. for the radii of molecules. The electron must therefore have great freedom of movement in the interstices even of solid bodies: and there appears to be no need to take friction into account, though the velocities are, say, one-third as great as that of light.

The view that electricity exists in separate natural units, the electrons (Stoney, Helmholtz), is now generally accepted. It is not necessary to assume the electron to be always associated with an atom to form an ion. If different atoms attract electrons with different amounts of force (v. Helmholtz, Faraday Lecture, 1881), the electron must somewhat resemble the atom and have inertia, and it must also be capable of being separated from an atom. If a positive and a negative electron unite to form a "neutron" (analogous to a molecule of matter), Trowbridge's results show that the ether insulates until the electric force at some point is sufficient to decompose the neutrons into electrons, whereupon it becomes a conductor of the same type as electrolytes. The ions undoubtedly present in the kathode stream are quite subordinate to the stream of electrons; but the proportion between the ion stream and the electron stream varies according to circumstances. On impact on a thin aluminium window the ions are filtered out; the electrons get through as Lenard rays. Lenard rays and kathode rays both carry negative electricity; both originate Röntgen rays; both colour haloid salts; both have magnetic and electric deflectability; both can excite luminescence; and so forth. The colouring of salts would be by the electrons attaching themselves to electro-negative atoms, forming ions, and liberating uncharged atoms of the metal in very small quantity. Fatigue of fluorescence would be due to the electrons, already lodged, repelling those following them; and also to a change of "colour," manifesting itself not as visible colour but as a lowering of fluorescent power. If each electron be small enough merely to deform an atom upon impact and not appreciably to move it as a whole, the energy lost by electrons upon impact would appear as energy of vibration of the atoms; and if the velocity of propagation of a deformation-disturbance in all atoms is the same and the time of encounter between an electron and an atom constant, the energy given up by the electron will be proportional to the density

of the substance of the atom. In a solid, as the electron threads its way between molecules, the number of impacts varies as the thickness of the solid; and for unit thickness, the coefficient of absorption will be proportional to the density of the substance of the atom, that is, very nearly, to the density of the solid: which is Lenard's law for the absorption of kathode rays. In gases there is much more free path: the number of impacts is proportional to the number, n, of molecules per unit volume and to the mean sectional area, πR^2, of each molecule; and as the coefficient of absorption also depends upon the density of the molecule, that is, varies as m/R^3, we have, taking these together, the coefficient of absorption $\propto n . R^2 . m/R^3$, or $\propto nm/R$, or ρ/R, where ρ is the density of the gas; and it therefore varies not only directly as the density of the gas, but also inversely as the molecular radius. This helps to explain the apparently abnormal absorption of hydrogen as observed by Lenard. The approximate equality of A/ρ (A being the coefficient of absorption) for different substances, solids and gases, would seem to show that it is only approximately normal impacts of an electron upon an atom that cause the former to lose kinetic energy; and if that be so, the true law for solids would be the same as that for gases. Also the approximate equality might come nearer to identity of value if we broke up the effect upon a molecule into the effects upon its component atoms. This theory explains why the Lenard rays, on emerging from the window, pass in all directions; the electrons emerge from the intermolecular interspaces in directions distributed at random. In metallic conduction there seems to be a Grothuss chain action, without any great rush of electrons at any one time and place; the nature of the metallic atom, by electromotive force (Helmholtz), favouring the local dissociations of the neutrons into electrons. That Lenard's rays can pass through gases at ordinary pressures, or at high vacua, in which the kathode rays could not have been formed, shows that the electrons are not stopped until they meet enough resistance to destroy their momentum, once they have been started. Röntgen rays may be explained, better than by the theory of their being electromagnetic pulses, by considering them as due to internal vibrations of the electrons, these vibrations being always damped by the associated atom unless the electrons are free, and therefore not accompanying ordinary light; and such vibrations would naturally originate where kathode or Lenard rays were being "absorbed" by the electrons being robbed of their translatory kinetic energy on impact. The wave-length would be small and the wave would pass freely through molecular interspaces, but would be liable to absorption near the surfaces of molecules. With such waves there would be no refraction: in reflection we would have to consider the surface of each molecule, not that of the aggregate of molecules, the result being diffuse scattering; polarisation could not be detected by our apparatus, since the rays coming through the interspaces would not be affected by the structure of the molecules of our crystals, &c. Further, such

waves would not be affected by the neutrons in the intermediately vibrating ether; but when they fell upon the electrons associated with atoms in matter, the damping effect of the atoms would tell, and the atom and electron would be set into some form of mutual action and reaction, say relative motion with fluorescent and photographic effects, or with escape of the electron from the atom, or with association of the electron with an atom to form an ion, as in the ionisation of gases. Air through which Röntgen rays are passing should emit Röntgen rays in every direction, as it does, for the rays are simply reflected from the individual molecules. As to the absorption of Röntgen rays by different substances, if n be the number of atoms per unit of volume, and R the radius of each, the quantity of surface encountered per unit area of wave front $\propto n^{\frac{2}{3}}R^2$ and the number of encounters per unit distance $\propto n^{\frac{1}{3}}$, so that the energy absorbed by the atoms $\propto nR^2$. If the energy absorbed on a collision of wave with atom also varies as the density in the atom, then here again the coefficient of absorption $\propto \rho/R$, as with Lenard rays. There are special resonance phenomena of fluorescence; but with Röntgen rays the most important factor is the density, though it is not the only one. That different Röntgen ray apparatus give out various radiations which are variously absorbed is not explained by the theory of thin electromagnetic pulses: but is explained by harmonics of a fundamental vibration of the electrons. Two colliding kathode streams could not give rise to Röntgen rays, because the collisions are so few. The present theory would lead to the conclusion that it ought to be possible to get an anode stream of positive electrons (qu. Becquerel rays), and also that the velocity of the kathode stream goes on diminishing as it travels, while that of Röntgen rays should be of the order of the velocity of light, perhaps less, for to such short wave-lengths the neutrons may act as if they loaded the ether. **J. J. Thomson** (Phil. Mag. 47. pp. 415–416, 1899) comments on the preceding paper. He had considered the view that the atoms are themselves made up of electrons, but thought it wanted clearness and led to difficulties, and preferred the view that the carriers were the small corpuscles of which the atoms could be supposed to be built up. A difficulty in the way of the electron theory is the large proportion of heat developed on the impact of kathode rays: electrons striking say aluminium would produce much less. A. D.

1163. *Velocity and Magnetic Deflection of Kathode Rays.* **E. Wiechert.** (Göttingen Nachrichten, 3. pp. 260–293, 1898.) —Experiments are described in which the velocity of the charged particles constituting kathode rays is determined by observations of their behaviour in a rapidly alternating magnetic field. The kathode rays are produced at one end of a long glass tube, and travel along its axis through a slit in a fixed screen to a second

slit, beyond which is a detector composed of phosphorescent glass. The second slit and the detector can be moved along the tube. Two air-condensers in series, charged by a Tesla oscillator, discharge through two equal loops of wire in parallel circuit, thus producing two alternating magnetic fields of calculable high frequency. One of these loops surrounds the glass tube longitudinally (so that the lines of force are transverse to the direction of kathode rays) between the origin of the rays and the fixed slit; the other loop is movable and surrounds the tube longitudinally between the second slit and the glass detector; we may suppose the planes of these loops to be vertical for the sake of description. When the kathode rays pass and the magnetic field is excited the rays broaden out into a fan-shape, the upper and lower boundaries being brighter than the rest and representing the deflection of the rays by the maximum magnetic field, positive and negative. By means of an auxiliary magnet the system is deflected until only the rays on one boundary of the fan pass through the fixed slit, so that rays will only start from the first slit for the second one when the magnetic fields have maximum intensity. If these rays travel with finite speed they may arrive in the movable magnetic field at a time when the field has zero intensity, thus undergoing no deflection between the second slit and the detector; or they may arrive when the field is opposite in phase to the original one and thus suffer maximum deflection in the opposite direction. Both these cases are obtained in the experiments; the velocity of the charged particles is thus deduced from the distance travelled by them in the period of alternation of the magnetic fields. The experiments give a value of one-tenth to one-fifth of the velocity of light for the speed of the kathode particles, and a probable value of $1{\cdot}0 \times 10^8$ to $1{\cdot}5 \times 10^8$ coulombs per gramme for the electric charge carried by them.

J. L. H.

1164. *Ball Coherers.* **E. Branly.** (Comptes Rendus, 128. pp. 1089–1092, 1899.)—After his experiments with metallic discs the author has tried the effect of substituting for them a row of balls 1 cm. in diameter. Since the large surface of the discs considerably reduces the density of the currents induced by the electric waves, it is to be expected that balls are much more sensitive, and this is actually the case. Brass gives no result, and lead gives only very feeble indications of sensitiveness, but ten balls of soft iron mounted one above the other show an initial resistance of 990 ohms, which is reduced to 60 by a spark of 1·5 mm. passing at a distance of 10 m. A slight shock sends it up to 1,300 ohms, and a second spark brings it down again to 80. Hard steel shows, under the same circumstances, the following succession of resistances: 600, 50, 2,060, 120, 2,520, 90. An important point is that a ball coherer, consisting of six hard steel balls, is just about as sensitive as a coherer of gold filings, which,

as we know, is highly sensitive. But to obtain uniform effects the shock used for decohering must be carefully graduated. Slight repeated shocks produce conductivity. A stronger single shock produces resistance. A very hard knock brings about a nearly permanent resistance, which is not annulled by ordinary waves. E. E. F.

1165. *Electrolytic Coherers.* **T. Tommasina.** (Comptes Rendus, 128. pp. 1092–1095, 1899.)—A very sensitive coherer may be constructed by enclosing a drop of mercury in a glass tube between two cylindrical brass electrodes. This fact was discovered by the author, and led him to investigate the properties of liquids with reference to electromagnetic waves. For this purpose he immersed a copper disc and a pendulum bob in distilled water. Both conductors had previously been coated with a film of electrolytic copper and well washed. On passing a current through the two electrodes, a black deposit was formed on the disc, which grew until a chain of particles, probably cupric oxide, joined the two electrodes. On increasing the distance between them, the current was not interrupted, but the chain grew until it again united both electrodes, even when 3 cm. apart. The chain followed the pendulum bob on displacing the latter to the right or to the left. The chain is sometimes invisible. If a small incandescent lamp is inserted in the circuit, and the bob suddenly removed to 3 cm., the lamp remains alight even before a visible chain is formed. When the distance between the electrodes is very small, a chain may be formed simply by the action of electromagnetic waves, and the author has constructed a coherer on that principle, with a very thin layer of distilled water. E. E. F.

1166. *Magnetic Decoherer.* **T. Tommasina.** (Comptes Rendus, 128. pp. 1225–1226, 1899.)—Working with coherers made of magnetic metals, the author has made the important discovery that the presence of a magnet immediately destroys the conductivity of the coherer created by the impact of the electromagnetic wave. He has applied this discovery to wireless telegraphy, by substituting an electromagnet for the tapping device used by Marconi. The electromagnet is fixed a few millimetres above the tube containing the filings, which is kept in a horizontal position. The circuit is formed by an accumulator, a resistance and a relay for opening and closing the circuit of the electromagnet, with two accumulators and a telephone receiver in a suitably shunted branch circuit. The adjustments once being made, the messages work perfectly with tubes containing steel, iron, cobalt, or nickel filings. The movement of the filings is clearly visible with the naked eye, and resembles a pulsation of striking regularity. The instrument is not put out of order by

the shaking of the floor nor by knocks given to the coherer. As in other cases where electric or magnetic processes are substituted for mechanical effects, much is gained in the way of precise control of the action in question. E. E. F.

1167. *Absorption of Electric Waves.* **E. Branly** and **G. Le Bon.** (Comptes Rendus, 128. pp. 879–882, 1899.) — The authors recently proved that a metallic enclosure, hermetically sealed, is an absolute protection against the influence of electromagnetic waves. They have since investigated the screening action of certain insulators or feeble conductors such as are met with in the practical work of wireless telegraphy. They operated with hollow blocks of cement, building stone, and sand. In each of the blocks a small cubical chamber was left free, to contain the coherer. It was closed by a thick iron door, through which the wires were conducted. The ringing of a bell indicated the impact of waves upon the coherer. Without a screen, the coherer responded to the exciter at a distance of 40 m. and more. It was found that the opacity of the substances tested depended much upon their nature, condition, and thickness. Sand and stone are very transparent, especially in the dry state. Portland cement is very opaque, wet sand almost equally so. To quote a few figures: Block of cement, with walls 10 cm. thick; the bell ceases to sound at a distance of 7 m. After drying, the distance becomes 12 m. The same, 30 cm. thick, is absolutely opaque while wet. Block of stone transparent. When wetted for several days the reaction ceases at 25 m. In the case of a block of stone, transparent when dry, the bell becomes silent at 25 m. if the stone is wetted for several days. E. E. F.

1168. *Propagation of Oscillations along Parallel Wires.* **W. B. Morton.** (Phil. Mag. 47. pp. 296–302, 1899.)—The author applies Heaviside's method to the treatment of electric waves along a circuit of parallel wires in the case where the wave trains are *damped* and where the circuit is *not distortionless.* The circuit is said to be distortionless when $R/L = K/S$, where R, L, K, and S are respectively the resistance, inductance, leakage conductance, and capacity, all per unit length of the line. The *velocity of propagation* of the waves along an ordinary circuit is shown to be slightly less than v, the velocity of free radiation, but reduces to v simply for the distortionless circuit. The *attenuation* of the waves in their passage along the leads is similarly shown to be slightly greater than the simple value generally used, viz., $e^{-\left(\frac{R}{2Lv}+\frac{K}{2Sv}\right)z}$, but reduces to this for the distortionless circuit. The reflection of the waves at a terminal bridge and the possibility of complete absorption

are also dealt with. It is shown that the reflection factor is more complicated than for the simple theory, and that complete absorption is not possible. Numerical values are then given, applicable to the circuit used by E. H. Barton (see 1899, Abstract No. 284) in recent experiments on attenuation. These show that the velocity of propagation is $\{1 - \cdot 00000035\}$ times that of free radiation, the attenuation is 1·000091 times that on the simple theory, and that the minimum reflection factor for a terminal resistance is 0·0004 instead of zero, and is to be obtained by using a resistance equal to (1·00009) Lv instead of Lv simply. E. H. B.

1169. *Oscillations Round a Theoretical Hertzian Oscillator.* **K. Pearson** and **A. Lee.** (Roy. Soc. Proc. 64. pp. 246–248, 1899.)—By a theoretical Hertzian oscillator is meant a Maxwellian "double point," and the investigation for such a double point with a *steady* wave train was originally made by Hertz. The theory was insufficient for two reasons (both recognised by Hertz himself), viz. (1), the actual oscillator has sensible extension, and (2) the wave train is not steady. The present investigation only attempts to remove the latter objection to Hertz's original theory; like that theory, it becomes less accurate as we approach nearer to an actual oscillator. The writers have also attempted to replace the well-known Hertzian diagrams of the field by a more complete series, representing the field for seven complete oscillations, and showing how the field for some 12 metres round the oscillator chosen gradually falls to nearly one-fiftieth of its maximum initial strength. They next deal with the type of waves propagated, their velocities and their phases. The following general conclusions are reached:—

(i.) Three waves of electromagnetic force may be considered as sent out from the oscillator, and not merely two, as supposed by Hertz. These are: (*a*) a wave of purely transverse electric force; (*b*) a wave of electric force parallel to the axis, briefly termed the wave of lineal electric force; (*c*) a wave of magnetic force.

(ii.) The velocities of these waves undergo remarkable changes in the neighbourhood of the oscillator, but these changes extend to distances which are greater than those within which a great proportion of Hertz's interference experiments were made.

(iii.) The point of zero phase for both (*a*) and (*b*) does not coincide with the centre of the oscillator, so that these waves appear to start from spheres of small but finite radius round the oscillator. A fourth wave, dealt with by Hertz, viz., the wave of magnetic induction, does not, as he supposes, start with zero phase from the origin, but with a finite phase. The wave in the equatorial plane is a compound of (*a*) and (*b*), and has a much more complex series of velocity changes than Hertz appears to have realised.

(iv.) The existence of the two electric force waves and the singular points, or surfaces, for the wave motion in the neighbourhood of the oscillator very possibly throw light on the difficulties which arise in Hertz's experiments. It would seem that such experiments should be made at distances greater than 6 to 7 ($\lambda/2\pi$) from the centre of the oscillator, or, roughly, about a wave-length from the oscillator. In Hertz's case they amount to about 10 metres—a distance at which Hertz rather terminated than started his interference experiments. Only at such a distance are the phase curves sensibly linear. D. E. J.

1170. *Copper Temperature-Coefficient.* (Elect. Rev. 44. p. 531, 1899.)—The usual correction 0·228 per cent. per degree F. is not justified by Clarke, Forde, and Taylor's experiments. They obtain an arbitrary parabolic formula which closely follows their experimental facts, viz. :—

$$\frac{R}{R_{32}} = 1 + \cdot 0023708\ (t-32) + \cdot 00000034548\ (t-32)^2.$$

A set of tables based on this result has been produced by these experimenters. M. O'G.

1171. *Electric Conductivity of Nitric Acid.* **V. H. Veley** and **J. J. Manley.** (Phil. Trans. 191. pp. 365–398, 1898.)—The acid was purified with scrupulous precautions, described in full; and the percentages of acid ranged from 1·30 to 99·97. At 0° C., the specific resistance, in true ohms, fell at first more, then less rapidly, from 19·924 at 1·30 per cent. to 1·722 at 30·42 per cent.; then rose slowly to 4·758 at 76·59 per cent., and then more rapidly to 73·663 at 96·12 per cent.; and again fell to 54·733 at 98·50, 26·554 at 99·27, and 25·688 at 99·97 per cent. The temperature-coefficients in the formula $R_t = R_0\ (1 \pm \alpha t \pm \beta t^2)$ for different concentrations are tabulated at page 391. Nitric acid between 96·12 and 99·97 per cent. behaves as a metallic conductor in possessing a negative temperature coefficient of conductivity. Sulphuric acid has an analogous maximum of density at 98·78 per cent. The authors find the curve representing the conductivity units in terms of percentages to be markedly discontinuous at $HNO_3 . 2H_2O$, at $HNO_3 . H_2O$, and at $2HNO_3 . H_2O$; and the temperature coefficients go through minima and maxima at these three hydrates and also at $HNO_3 . 3H_2O$. A. D.

1172. *Capacity of Telephone-Cables.* **F. Breisig.** (Elektrotechn. Ztschr. 20. pp. 127–131, 1899.)—The mutual relation of the conductors in a sheathed twin-cable can be approximately

represented by three condensers connected in series, with the terminal plates of the first and last condensers connected to earth. The capacities of the two intermediate connecting wires, *i.e.*, of the wire between the first and second, and of the wire between the second and third condenser of the series, are analogous respectively to the capacities of the two conductors in the twin-cable, and expressions can at once be written down for the capacity of each conductor with respect to the earth, and for the capacity of each with respect to the other. This analogy can be extended to the case of a telephone cable containing more than two conductors. A further approximation can be made by assuming that the multifold conductors are arranged symmetrically within a metal cylinder. The author considers one particular pair of conductors of this symmetrical system, and on the theory of electric images traces the corresponding equipotential surfaces. An expression is deduced for the capacity of the pair of conductors in terms of the diameter of the wire, the distance between the two conductors, and the radius of the containing cylinder. R. A.

1173. *Detecting Faults on Picking up Submarine Cables.* **E. Jona.** (Electrician, 43. pp. 15–16, 1899.)—Currents are induced in the turns of cable which pass on to the picking-up drum. The galvanometer is connected between the picked-up end of the cable and the earth. The galvanometer throw shows a sudden alteration as soon as the fault passes over the drum. Details of a satisfactory trial at sea in 1898 are given. M. O'G.

1174. *Detecting Faults on Picking up Submarine Cables.* **W. J. Murphy.** (Electrician, 43. pp. 12–13, 1899.)—The variations of a high resistance fault which is being raised from the bottom increase the difficulties. An induction method similar to E. Jona's (see preceding Abstract) was tried in 1891. The use of high frequency, the earthing of the far end, the use of a telephone, a secohmeter, a Wehnelt interrupter and a condenser on the ship are suggested. M. O'G.

1175. *Earth-currents in Germany.* (Archiv. Post. Tele. 4. pp. 110–112, 1899.)—Since 1881, observations have been made and recorded at the telegraph stations of the principal towns in Germany in order to determine the strength, direction, and duration of earth-currents over a large continental area. The currents follow a very regular sequence, with a primary epoch of twenty-four hours. They are greatest at midday, and least at midnight; the current-curve between those two points takes a wave

form of approximately thirty-six periods a day, with a submaximum at 4 a.m. The direction is at midday south-east, afterwards veering round to south, west, north, and east. At 4 a.m. the direction is opposite to that at noon. At night the reversals are less regular than during the day. In addition to the diurnal variations, the currents undergo a sudden diminution between November and December of each year, and an equally sudden rise in January and February; they are strongest in spring and autumn, weakest in winter, and almost as strong in summer as in autumn. The reversals are less regular in winter than at other times of the year. The similarity of year to year observations is very remarkable. R. A.

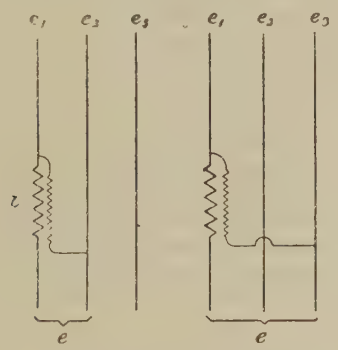
1176. *Comparing Low Resistances.* **J. B. Pomey.** (Écl. Électr. 18. pp. 247–249, 1899.)—This paper investigates the best conditions for comparing two low resistances by shunting each of the coils of a differential galvanometer with one of them. E. C. R.

1177. *Strain and Thermoelectric Properties.* **M. Maclean.** (Roy. Soc. Proc. 64. pp. 322–330, 1899.)—Kelvin describes in vol. ii. of his Mathematical and Physical Papers a number of qualitative experiments to determine the direction of thermoelectric currents in the same metal when one part of it is left unstrained and the other is strained in various ways. The object of the experiments described in the present paper was to determine the *magnitude* of the thermoelectric effects in similar cases. Junctions were formed between pieces of drawn and undrawn wire made from specimens of copper in different states of purity, and also from lead, reostene, platinoid, German silver, and manganin. The currents produced between the drawn and undrawn portions (one junction being heated in a glycerine bath and the other kept at the temperature of the room) were measured by means of a low resistance galvanometer, and the values in micro-amperes are given by the author. From these were deduced the thermoelectric differences in microvolts per degree difference of temperature. The analyses of the specimens of copper wire and the densities and specific resistances of the drawn and undrawn wires of the various materials are also given in the paper. J. J. S.

1178. *Luminous Electrolytes.* **E. Lagrange.** (Comptes Rendus, 128. pp. 1224–1225, 1899.)—The author has been studying the luminosity of the layer of dielectric surrounding an electrode since 1891. He discovered and described the "unstable" phase which is now known to be accompanied by

rapid intermittence. After the publication of Wehnelt's contrivance, he set himself to produce the unstable phase at the kathode instead of the platinum anode. The interest attached to this attempt lies in the fact that at the anode only a noble metal can be used, in consequence of the evolution of nascent oxygen, whereas the hydrogen developed at the kathode would not even perceptibly attack iron. The main difficulty lies in the rapid rise of temperature of the liquid, which soon brings about the stable condition with continuous current. The author, therefore, constructs the kathode of small bars of copper attached to a large sheet of the same metal outside the liquid. The sheet presents a large cooling surface, which keeps down the temperature. The sheet may also be replaced by a copper vessel containing cold water constantly renewed. The author has thus succeeded in interrupting currents of 40 to 100 amperes, with or without inductance in the circuit, and in imitating Wehnelt's induction-coil phenomena. E. E. F.

1179. *Measurement of Phase-Difference in Induction Motors.* **C. Breitfeld.** (Elektrotechn. Ztschr. 20. p. 120, 1899.)—Let a three-phase induction motor with star coupling of circuits be connected to three-phase mains, and let e_1, e_2, e_3 stand for the P.D.s across the circuits. The phase-difference φ between the



P.D. and current in any circuit may be determined from the two deflections x_2 and x_3 of a wattmeter connected in the two ways shown in the accompanying diagram. If k stand for the wattmeter constant, then, in the first position shown, the power is—

$$kx_2 = ei\cos(\phi - 30°),$$

and in the second it is—

$$kx_3 = ei\cos(\phi + 30°),$$

from which $\tan\phi = \sqrt{3}\,\frac{x_2 - x_3}{x_2 + x_3}$. The author has not tested the method experimentally. A. H.

1180. *Measurement of P.D. at Feeding-Points.* **J. Teichmüller.** (Elektrotechn. Ztschr. 20. pp. 246–247, 1899.)—In German Central stations the mean value of the P.D. at the various feeding-points of a network is commonly ascertained by bunching together all the positive and all the negative pilot-wires and connecting them to a single voltmeter. The same voltmeter is frequently also used for ascertaining the P.D. at single feeding-points or groups of feeding-points—a measurement which will indicate in how far the network performs its function of equalising the potential. From considerations of economy the pilot-wires are small (1 mm. dia.), and are embedded in the insulation of the feeders. All the pilot-wires are adjusted to the same resistance by means of equalising resistances connected in series with them. It is usual to graduate the station voltmeter with a resistance in its circuit equal to that of a pilot-wire, so that when connected to a pair of pilot-wires it will correctly give the P.D. at the feeding-point. It is obvious that if the same instrument is used for measuring the mean P.D. of all the feeding-points, or any group of them, its readings will be too high, on account of the reduced drop due to parallel connection of the wires. The author shows that with ordinary electromagnetic instruments and lengths of pilot-wire such as occur in practice, the error may be considerable, amounting to as much as 5 per cent. in some cases. He then describes an arrangement recently patented by himself, and introduced into practice by Siemens and Halske, by means of which the difficulty is overcome. All voltmeters are calibrated with a series resistance of 100 ohms (which is never exceeded by any pilot-wire in practice), and the circuit of each pair of pilot-wires is made up to this amount. The voltmeter switch consists of a circular plate of metal furnished with a number of contacts of varying width, so that the switch may be made to cover one, two, or more of the contact-pins connected to the pilot-wires. At the same time, by means of an additional contact which glides over a number of segments, resistances are introduced into the voltmeter circuit, of such amounts as to always maintain the total resistance outside the instrument at 100 ohms. A. H.

1181. *Wehnelt's Interrupter.* **E. Thomson.** (Elect. Engin. N.Y. 27. pp. 239–240, 1899.)—The author gives a general account of the Wehnelt current-interrupter, and then describes the ordinary effects. The response of the apparatus to the closing of the circuit is extremely quick. In taking radiographs of the thorax, the closing of the circuit can be so timed with the breathing that the ribs are always in the same position when exposed to the rays. (Elect. World and Elect. Engin. N.Y. 33. pp. 334–335, 1899.) —This interrupter furnishes a means for performing experiments hitherto regarded as requiring alternating currents. The repulsion of rings, rotation of discs, and similar phenomena can be demon-

strated, using a coil of comparatively few turns wound upon an iron wire core. Cores for the coils used with the interrupter should generally be of the open magnetic circuit type. The author has, however, devised for this purpose a closed-circuit core; it has an auxiliary reverse winding which, when the interrupter is "open," magnetises the iron oppositely to the primary turns. The effect is similar to that of an alternating current. R. A.

1182. *Interrupters for Induction Coils.* **F. Dessauer.** (Elektrotechn. Ztschr. 20. pp. 220–223, 1899.)—The author reviews critically the various forms of interrupter which have been devised from time to time. The ordinary vibrating contact-breaker is very serviceable for coils of moderate size. It is simple, clean, and cheap, but not very suitable for coils of large size, as there is then the danger of the platinum contacts becoming fused together and thus producing a short circuit; further, this form of contact-breaker is incapable of giving high-frequency interruptions. For securing the latter, motor-driven mercury interrupters are used. The two great drawbacks to mercury interrupters are: (1) The excessive amount of oxidation, which soon interferes with regular working, and necessitates frequent cleaning of the mercury; (2) The fact that the surface of the mercury is thrown into waves, so that if the contact-pin happens to descend into the trough of a wave it may miss contact. In order to get over this latter difficulty, Kohl and Ernecke make the mercury vessel hour-glass shaped, the contact-pin dipping into the mercury at the narrow part of the vessel; but the difficulties arising from oxidation are thereby increased, on account of the smaller surface of mercury. A considerable improvement is due to Bose, who introduced two mercury interrupters, driven by cranks 180° apart, one at each end of the motor spindle; there is, however, considerable difficulty in accurately adjusting the positions of the two mercury vessels so as to get the same duration of contact from each. This difficulty is absent in the form due to the author, in which both interrupters are at the same end of the spindle, and the mercury vessels communicate with each other, so that the mercury is always at the same level in both. For very high frequencies, the mercury interrupter due to Boas deserves notice: a vertical tube of glass, the lower end of which dips into a mercury vessel, and the upper end of which is bent at right angles to the length of the tube, is rotated at a high speed; the horizontal rotating jet of mercury is directed against a toothed or perforated metal ring. In conclusion, the author describes his modification of the ordinary platinum contact-breaker; this is noticed in the following abstract. A. H.

1183. *Interrupter for Induction Coils.* **F. Dessauer.** (Zeitschr. Elektrochem. 5. pp. 357–359, 1899.)—The modification intro-

duced by the author consists in using two contacts (one on each side of the spring) instead of one, so that as the spring vibrates it closes and opens the circuit twice during each complete oscillation. At first sight the arrangement appears impracticable, for one might expect the armature to remain in contact with the core once it is attracted towards it and the circuit closed. But the resilience of the vibrating spring is sufficient to tear the armature away from the magnetised core and break the circuit. The advantages claimed for this arrangement are:—longer contact, and hence longer sparks for the same make-and-break frequency, and double the frequency for the same period of vibration of the spring.

A. H.

1184. *Wehnelt's Interrupter.* **A. Blondel.** (Comptes Rendus, 128. pp. 876–877, 1899.)—The author reproduces some oscillograph curves showing that at 40 periods per second the current is first established as in all inductive circuits. The electrolysis increases until a gaseous envelope is produced round the anode. Then there is a sudden interruption of the current, and, at the same time, an enormous increase in voltage. Then both the current and the pressure reassume their initial values, and the action begins again.

Under these conditions the phenomenon of interruption only occasions one single aperiodic impulse. The energy $\frac{1}{2}LI^2$ accumulated in the self-induction, and liberated by the interruption of the current, causes the condenser formed by the polarised anode in the electrolyte to be charged at high potential. This condenser destroys itself by discharging in an arc which is formed between the platinum and the electrolyte, and drives away the dissociated oxygen. The anode is therefore immediately freed from gas, and is again in contact with the liquid which condenses the vapour, if any remains, and permits the current to flow again immediately. This action may be approximately compared with that of a hydraulic ram or a pulsometer. This explanation allows one to understand the necessity of a certain proportion between the self-induction and the anode without it being necessary to liken the phenomenon to a true resonance. One understands also why the employment of a high voltage, which increases the rapidity of the electrolysis, can increase the frequency. Finally, the form of the pressure curve suffices to explain the large increase of the mean pressure at the terminals of the cell, pointed out by Wehnelt and Pellat. The oscillograph used did not lend itself to an examination of the action at high frequencies, but one may fairly believe that the phenomenon preserves the same character whatever the frequency.

E. E. F.

1185. *Diffraction Galvanometers.* **P. Weiss.** (Comptes Rendus, 128. pp. 876–877, 1899.)—The sensitiveness of a

galvanometer can, according to the author, be almost indefinitely increased by constructing it on a smaller and smaller scale, or by employing a greater and greater optical enlargement for reading the angles. But a limit is set by the resolving power of the mirror. A mirror of 1 cm. diameter should, according to Foucault's rule, separate two readings 12 sec. apart. Practically about 5 sec. can be observed, and this, on account of the doubling, means an actual deviation of 2·5 sec. But the same author has devised a means of considerably increasing the sensitiveness by diffraction. He uses a mirror, $1 \times 0{\cdot}4$ cm. in area, suspended with its greater length in a horizontal position. The centre of the mirror is blackened, while the ends, 4 mm. $\times$ 3 mm., are left bare. The radius of curvature of the mirror is 4 m. It is illuminated by an incandescent filament placed at the centre of curvature. The rays reflected by the mirror produce, at the same distance, the usual phenomenon of diffraction at infinity for the case of two openings. The enlarged image of the filament is seen in the focal plane, traversed by two black fringes, which are sharply defined. On taking the position of one of them as a datum, a micrometric eye-piece will easily discover a displacement of 0·025 mm. This is less than a second of arc, and at least four times as sensitive as the usual method. E. E. F.

1186. *Ampere Balance.* **W. E. Ayrton** and **J. V. Jones.** (Elect. Engin. 22. pp. 653–654, 1898. Paper read before the British Association at Bristol.)—The proposed new instrument is distinguished by the fact that the counterpoise weight is determined purely by calculation based on the dimensions of the instrument, the number of turns in the coils, and the value of g where the balance is set up. The authors remark that "the proposed ampere balance and the existing ampere standard will differ exactly in the same way as do a Lorenz apparatus and the Board of Trade ohm standard, verified 1894." G. B. M.

1187. *High Resistance Standards.* **F. B. Fawcett.** (Phil. Mag. 46. pp. 500–503, 1898.)—Gold-platinum films are deposited in vacuo on a glass plate by means of a grid-shaped kathode. The film is then boiled for several hours under reduced pressure in an oil-bath; in this it is then hermetically sealed. Seven months' observation on three such films show percentage variations of resistance as follows:—

A. $+0{\cdot}0130$ to $-{\cdot}0082$. B. $+0{\cdot}0055$ to $-0{\cdot}0086$
C. $+0{\cdot}0005$ to $-0{\cdot}0004$,

the mean resistances being 97110, 161360, and 502500 ohms respectively. G. B. M.

1188. *Mercury Voltameter.* **L. Gourwitch.** (Electricien, 17. pp. 66–67, 1899.)—This is a description of a mercury voltameter which can be used for the measurement of electric currents of any magnitude. W. G. R.

1189. *Therapeutic Electrostatic Apparatus.* **W. J. Morton.** (Elect. Engin. N.Y. 27. pp. 245–246, 1899. Read before the Société Française d'Electrothérapie, January, 1899.) — Priority concerning the applications and terminology of interrupted currents from induction machines for the purpose of producing continuous muscular contraction. Morton also suggests putting the patient on an insulating stool and connecting the electrodes to one of the conductors of the machine, which conductors are placed so as to maintain a spark-gap. H. B.

1190. *Photographing Variable Current Curves.* **H. J. Hotchkiss.** (Phys. Rev. 8. pp. 152–160, 1899.) — This apparatus, which is portable, consists of two Deprez-type galvanometers, mounted one above the other, each with a soft iron moving part 1 mm. wide, 1·9 mm. long, and 0·06 mm. thick, mounted with a mirror one-third as large as itself on a quartz fibre, the latter being supported at both ends by a quartz bow or rod about 1 mm. diameter and 1 cm. long. The iron is between the poles of a strong permanent or electro magnet, and is deflected by the current passing through coils whose field is at right angles to the controlling field of the permanent magnet. Needles have been made having a natural frequency of over 8,500, and with a strong field and stiff fibre a frequency of 10,000 can be obtained. Sunlight or arc-light is directed through two narrow slits in the side of the containing box upon the two mirrors. From the mirrors the two beams are reflected upon a horizontal slit in the box containing the revolving drum. As the needles are deflected by the current, the spots of light move along the slit and trace the curves in the film, which moves rapidly at right angles to the slit. The drum box may be removed and replaced by a slide-way for using plates.

The paper gives illustrations of the apparatus and photographs of various curves of alternating currents obtained with it.

No method of artificial damping is used in this apparatus.

E. C. R.

1191. *New Transformer Diagram.* **F. G. Baum.** (Phys. Rev. 8. pp. 95–111, 1899.)—An analytical investigation of the problem of the transformer, accompanied by a number of vector diagrams illustrating the results of the analysis. The author obtains expressions for the primary and secondary currents for

any given resistance and reactance in the secondary, and arrives at the following results: Any transformer may (so far as the *primary* current taken by it is concerned) be replaced by a single coil having a coefficient of self-induction equal to $R_1 (L_1/R_1 + L_2/R_2)$, a resistance equal to that of the primary, and an E.M.F. whose value is $\sqrt{B^2+C^2}$ times the primary P.D.; this apparent E.M.F. being in advance of the real primary P.D. by an angle $\tan^{-1}\frac{B}{C}$. In the above, R_1 and R_2 stand for the resistances of the primary coil and secondary *circuit*, and L_1 and L_2 for the self-inductances of the primary and secondary *coils* respectively; B and C being defined by the equations—

$$B = \sin\phi + \tan\theta_2 \cos^2\theta$$
$$C = \cos\phi + \tan\theta_2 \sin\theta\cos\theta,$$

in which ϕ is the angle between $\mathbf{H}$ and $\mathbf{B}$; $\theta_2 = \tan^{-1}\frac{L\dot{p}}{R_2}$; and θ is the angle of lag or advance (due to inductance or capacity, or both) of the secondary current from its normal phase at right angles to the magnetic flux. In the same manner, so far as the *secondary* current is concerned, the transformer may be replaced by a single coil having a resistance equal to that of the secondary *circuit*, a self-inductance equal to $R_2 (L_1/R_1 + L_2/R_2)$, the E.M.F. acting on the coil being taken as $\frac{EM\dot{p}}{R_1}\cos\theta$, where E is primary P.D., and M mutual inductance of two coils ($M = \frac{N_2}{N_1}L_1$). The main advantage claimed by the author for his method is that it enables us to deal with either circuit independently of the other.

A. H.

1192. *Magnetic Induction in Iron Rods.* **J. L. W. Gill.** (Phil. Mag. 46. pp. 478–494, 1898.) The rod examined, which is straight, is fixed co-axially inside a standard solenoid, and a small search-coil, in circuit with a d'Arsonval ballistic galvanometer, is adjustable, by a sliding arrangement, at any desired position on the rod. The solenoid and a secondary coil serve to calibrate the galvanometer. By observing the induced current when the field is reversed, the induction across a section of the rod is calculated. For specimens of round or square section and length less than thirty times the diameter of the section, the observations show that if B_o is the maximum induction, B that at a distance x from the centre, then the following relation is very nearly true:—

$$(B/B_o)^{\frac{3}{2}} + (x/a)^2 = 1,$$

a being a constant depending on the dimensions of the specimen.

When the rod is put through a cycle, let L_t be the average loss

of energy per unit volume due to hysteresis; then there is a relation—

$$L_1 = KB_1^{1\cdot6}$$

where—

$$B_1 = \sqrt[1\cdot6]{B^{1\cdot6}\text{ mean.}}$$

The author calculates B_1 from this formula: the results show that for specimens of different relative dimensions the ratio B_1/B_n does not vary much, and is constant when the length is less than thirty times the diameter: its value is then ·768.

G. B. M.

1193. *Magnetism in Ferro-Nickels.* **L. Houllevigue.** (Journ. de Physique, 8. pp. 89–94, 1899.)—The author suggests a possible physical explanation of the existence at the same temperature of magnetic and non-magnetic forms of the same ferro-nickel alloys, the former being say 2 per cent. greater in volume than the latter (Hopkinson). These alloys are much more heterogeneous than their moderate thermal conductivity would have led us to expect. In nickel, traction diminishes while pressure increases the magnetic susceptibility; in iron below the critical strength of field the action is the converse of this. If each iron nucleus be compressed sufficiently by its nickel shell (*i.e.*, iron and nickel or some nearly equivalent alloys of the two) the iron would, in moderate fields, have no magnetic susceptibility at, say a pressure of 400 kgrms. per sq. mm. The equilibrium of pressure reached in the pasty state would be disturbed so as to produce such a pressure on cooling. Then break the shell mechanically and the pressure is relieved and the system re-assumes, with increase of volume, its magnetic susceptibility. Cold may do the same thing, and the more readily so the thicker the nickel shells. The modulus of elasticity also alters by 10 per cent. on transition to the magnetic condition: and the relation of the one to the other is discussed. A. D.

1194. *Diurnal Variations of Magnetic Disturbances in Polar Regions.* **G. Lüdeling.** (Berlin Akad. Sitzber. 14. pp. 236–246, 1899.)—Lüdeling had established (Abstract No. 71, 1899) that, in polar regions, the vector diagrams of the magnetic elements show a counter-clockwise movement, if all days are considered, and a clockwise movement—as generally in medium latitudes—if quiet days are alone taken into consideration. In this paper he deals with the diurnal disturbances, proceeding after the manner of P. A. Müller's inquiry into the magnetic elements of Pawlowsk, 1884. The calculations and the vector diagrams based upon them concern eleven stations, situated in high latitudes, from Pawlowsk, lat. 59° 41′, up to Cape Thorsden,

lat. 78° 28′, and, as before, the summer months of 1883. The radius vector of the disturbance diagrams describes a counter-clockwise movement, whilst the normal daily variations follow the hands of the clock. The diagrams are, however, fairly symmetrical with regard to the magnetic meridian and appear stretched out in that direction, and the disturbing forces seem to be inversely proportional to the horizontal force. Kingua Fjord again makes the exception. This station is near the magnetic and auroral north poles, and shows a very small X-component (south-north) and abnormal earth-current phenomena. The unknown disturbing forces of polar stations have obviously a period of twenty-four hours. H. B.

1195. *Bar Magnets.* **V. Guillet.** (Ecl. Electr. 18. pp. 441–446, 1899.)—The apparatus used by the author consists of a hollow cylinder of copper, to the upper portion of which is fixed a simple vertical rectangular copper frame, the whole being suspended by a fine wire provided with a torsion head. The current is led into the cylinder by a number of very fine loose silver wires, flows up the cylinder, at the top bifurcates, one half of it passing up each half of the rectangular frame, which it leaves at the top by another series of fine silver wires. Two adjustable frames are provided for holding the bar magnet which is being tested; by means of the first frame, the magnet may be held with its axis vertical and coincident with that of the hollow cylinder, by which one end of it is completely enclosed, so that the whole of the magnetic lines thread themselves through the cylinder; by means of the second frame, the magnet may be held in a horizontal position, with its axis at right angles to, and passing through the centre of, the rectangular frame above the cylinder. The torque acting on the cylinder in the first position of the magnet is a measure of the intensity of magnetisation; while the second position affords a means of determining the position of the "pole" of the magnet, the position of the magnet being adjusted until it exerts maximum torque on the rectangle. By means of this apparatus, the author studies the effects of temper and various methods of magnetisation, and of ratio of length to diameter, on the magnetisation and position of the poles of the magnet. He finds that the distance between the poles increases with increasing intensity of magnetisation. A. H.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

1196. *Crystalline Structure of Metals.* **J. A. Ewing** and **W. Rosenhain.** (Roy. Soc. Proc. 65. pp. 85–90, 1899.)—Etched polished surfaces of iron, mild steel, nickel, and various other metals, showing the crystalline structure of the material, develop, if the etched piece be subjected to stress, a number of parallel bands within the crystalline areas. The direction of these bands, which under the microscope appear like crevasses, varies in different crystals and bears no relation to the direction in which the load is applied, although at first the average general tendency is for them to be markedly at right angles to the direction of pull or pressure. As the material becomes more and more permanently deformed, one or often two other sets of lines occur, crossing those first formed. Polished but unetched surfaces show all these lines equally well. Oblique illumination proves the lines to be due to superficial differences in level, and points to their being caused by slip occurring within the crystals along planes of cleavage, or gliding planes. The crossing lines are similarly due to slips subsequently developed along different lines of cleavage. Silver, gold, copper, lead, bismuth, tin, gun-metal and brass, but not hard steel, can be readily made to show these lines under magnifications of from 140 to 1,000 diameters.

It would thus appear that the plasticity of metals is due to numerous internal slips occurring at intervals along cleavage surfaces within the crystals, whereby the crystal-grains are deformed. Slipping in three directions enables the grain to accommodate itself to its envelope of neighbouring grains. The flow produced by these intra-crystalline slips involves an expenditure of work in an irreversible manner. The metal is therefore plastic, because it is made up of irregular crystals within which these slips may occur—each crystalline grain changing its shape through slips occurring within itself, and its position through slips occurring in other grains. W. G. M.

1197. *Velocity of Crystallisation.* **A. Bogojawlensky.** (Zeitschr. Phys. Chem. 27. pp. 585–600, 1898.)—Various substances were examined by melting them in clean glass U tubes of 2 mm. internal diameter, with limbs 15 and 18 cm. long respectively, and partly immersing these tubes in a bath of water or glycerine heated to the melting-point of the substance examined. The usual precautions were taken to prevent premature solidification on the walls of the tubes. The linear measurements were taken by means of glass scales clipped to the limbs of the U tubes.

Crystallisation was started by a nucleus of the solid substance introduced on the end of platinum wire at the desired temperature of examination, which ranged commonly from 10° to 60° below the fusing temperature. Thus Tammann's earlier observations were, with certain substances, confirmed, but not so with others. With benzyl, sulphonal, picric acid, mannite, erythrite, santonin, and other substances the velocity of crystallisation, expressed in mm. per minute, increased with the number of degrees below the fusing-point at which the crystallisation was started, up to a certain limit beyond which it was constant, no matter to what extent the material was cooled, within the limits of practicability. This number depended upon the substance and upon its purity. For mannite and santonin it was reached at 25°, for benzyl, sulphonal and picric acid at 35°, and for erythrite and antipyrin at 60° below the normal. The velocity ranged from 36 mm. per min. in the case of santonin to 880 mm. in the case of picric acid. The limit of constant velocity has not yet been reached in the case of dinitrophenol and coumarin, although the former has been crystallised from sur-fusion at a temperature 75° below the normal. W. G. M.

1198. *Velocity of Hydrolysis of Maltose.* **A. von Sigmond.** (Zeitschr. Phys. Chem. 27. pp. 385–400, 1898.)—The following are a few of the results of the author's work: The hydrolysis of Maltose follows Wilhelmy's Law, and is therefore a reaction of the first order. The constant expressing the rate of hydrolysis is a function of the temperature, and this function can be expressed by Arrhenius' exponential equation for the inversion of cane sugar. Hence the reactivity of maltose is increased as the temperature rises, and, as in the case of raw sugar, there may be considered to exist, under given conditions, a constant ratio between active and inactive maltose molecules. In the exponential equation, $A_n = 17127{\cdot}29$, for maltose hydrolysis, determined at temperatures between 63·7° and 83·76°. The corresponding constant for cane sugar at temperatures below 69·24° is $A_n = 12820$. Hence the hydrolysis of maltose is affected more strongly by temperature than is the inversion of cane sugar. The concentration of maltose solution increases its reactivity. The rate of reaction varies with the conditions, but at 69·24°, and in the presence of normal acetic acid, the rate of reaction of cane sugar undergoing inversion is 1132·63 times greater than that of maltose during hydrolysis. Finally, not only the reactivity of the acids, but the nature and quantity of the sugar used, are found to exert a considerable influence on the hydrolysis of the various sugars. W. G. M.

1199. *Reaction Velocity.* **A. A. Noyes** and **G. J. Cottle.** (Zeitschr. Phys. Chem. 27. pp. 580–584, 1898.)—The reaction examined is that expressed by the following equation :—

$$2AgC_2H_3O_2 + HCO_2Na = 2Ag + CO_2 + HC_2H_3O_2 + NaC_2H_3O_2$$

or, in accordance with the dissociation theory—

$$2Ag + HCO_2' = 2Ag + CO_2 + H'$$

The experiment was conducted at 100° C. by breaking a small tube containing a solution of sodium formate within a larger tube carrying a solution of silver acetate, and after a thorough stirring, watching the progress of the reaction by titrating a portion of the liquid with potassium permanganate. It was thus found that the rapidity of the reaction was proportional to the concentration of the sodium formate solution and to the square of the concentration of that of the silver acetate, which is in agreement with theory. W. G. M.

1200. *Reaction Velocity.* **A. v. Hemptinnes** and **A. Bekaert.** (Zeitschr. Phys. Chem. 28. pp. 225–240, 1899.)—The work of Menschutkin (Z. P. Ch. 5. p. 589. & 6. p. 41) on the combination of $N(C_2H_5)_3$ and C_2H_5Br is extended to a large number of pure and mixed solvents. The chief results are :—

1. The constant for C_2H_5Br bears a nearly constant ratio to that for C_2H_5I in benzene, chlorbenzene, xylene and acetone ; in the alcohols it is somewhat lower.

2. Increase of temperature increases the constant in the same ratio in benzene and in acetone.

3. Many binary mixtures give a constant differing little (5 to 15 per cent.) from that calculated by the rule of mixtures : others, like the alcohols mixed with benzene, xylene, acetone, &c., are 30 to 80 per cent. higher than the calculated values.

4. Ternary mixtures give constants which differ more, but can be approximately calculated by regarding them as mixtures of one constituent (benzene, xylene, &c.), with a binary mixture (determined as above). B. B. T.

1201. *Velocity of Inversion.* **E. Cohen.** (Zeitschr. Phys. Chem. 28. pp. 145–153, 1899.)—The inversion velocities of 10 per cent. cane sugar by N/2 to N/128 HCl in water and 20 per cent. and 50 per cent. alcohol are determined : some of the constants found are as follows :—

Conc. HCl	N/2	N/8	N/32	N/128
Water	775×10^{-6}	157×10^{-6}	365×10^{-7}	852×10^{-8}
20% Alcohol ..	...	152 „	347 „	830 „
50% Alcohol ...	640 „	114 „	248 „	573 „

The ratio—velocity in alcohol to velocity in water—increases with diminishing concentration of acid, and is constant at 1·04 for 20 per cent. and 1·49 for 50 per cent. alcohol: the ratio is the same for 5 per cent. The velocity in each solvent is proportional to the concentration of H ions (as calculated from the conductivity): the author therefore retracts his former statement. (See following Abstract; also 1898, Abstract No. 538.) B. B.T.

1202. *Theory of Reaction Velocity.* **S. Arrhenius.** (Zeitschr. Phys. Chem. 28. pp. 317–335, 1899.)—The author refers to his former hypothesis (Zeitschr. Phys. Chem. 4. pp. 231–234, 1889) of active and inactive molecules to explain reaction-velocity. The proportion of active molecules increases rapidly with the temperature; in the case of Zn and H ions the maximum is reached, whence the slight temperature-coefficient of the solution-velocity of zinc in acids (Ericson, Bihang d. Stockholm Accod. 22. 2. p. 21, 1897). The influence of pressure (Rothmund Zeitschr. Phys. Chem. 20. p. 175) and the velocity of crystallisation (contrary to Tammann's calculation) (Wied. Ann. 62. p. 292, 1897) agree with this theory.

The increase of velocity in catalytic processes with increase of concentration, is shown to be the same as the increase of osmotic pressure; cane sugar obeying in both cases the formula $G/p = A(1 + 0{\cdot}013p)$ where G is the velocity (or osmotic pressure), p the percentage of sugar, and A a constant.

The osmotic partial pressure must therefore be substituted for the concentration in the application of the law of mass action: the theoretical proof by means of semi-permeable membranes is given by van't Hoff (Zt. P. Ch. 1. p. 500). The increase in velocity on adding foreign substances (salts, &c.) is similarly explained. This increase is in first approximation proportional to the amount of foreign substances whatever the concentration of the reacting substances; the change of ionisation in the latter is, of course, corrected for. The effect of increased viscosity on adding foreign substances is shown by theoretical (kinetic) considerations to be slight.

The author controverts Cohen's statement that the degree of ionisation cannot be calculated from the conductivity (see 1898, Abstract No. 538, and Zeitschr. Phys. Chem. 25. pp. 1–45), pointing out that the diminution of reaction-velocity in alcoholic solutions (Kabulokow and Zacconi), just as the increase with rise of temperature, &c., must depend on some such specific action of the solvent as the author's theory predicts. Van Laar's argument for Cohen's statement based upon the solubility determinations of Goldschmidt and Marseveen (see 1899, Abstract No. 1056) is erroneous. When the variability of the ionisation with the concentration is taken into account, the observed values agree well with those calculated from the ionisation as usually determined (from conductivity). (See also preceding Abstract)

B. B. T.

1203. *Alloys of Iron and Nickel.* **F. Osmond.** (Comptes Rendus, 128. pp. 304–307, 1899.)—The points of transformation of alloys of nickel and iron are determined by observing the temperatures at which the magnetic properties disappear on heating (A) and reappear on cooling (B). For alloys containing more than about 26 per cent. of nickel these temperatures are probably the same, the apparent difference being due to experimental error. The following table contains some of the observed values :—

Percentage composition.				
Carbon.	Manganese.	Nickel.	A.	B.
0·19	0·79	0·27	735°	715°
0·17	0·68	7·65	710	530
0·16	0·32	24·75	540	27
0·61	0·46	26·20	0	<0
0·23	0·49	31·44	138	124
0·30	0·68	43·04	401	357
0·08	0·41	69·20	590	557
0·12	0·38	88·95	488	457
0·12	0·55	98·50	384	345

T. E.

1204. *Occlusion of Hydrogen and Oxygen by Palladium.* **L. Mond, W. Ramsay,** and **J. Shields.** (Phil. Trans. 191. pp. 105–126, 1898.)—Palladium black, obtained by precipitation, contains 138 volumes of oxygen (1·65 per cent.) and 0·72 per cent. of water. When heated in oxygen it absorbs the gas continuously up to a red heat, forming a dark brown substance which is, without doubt, an oxide or mixture of oxides, since it does not lose oxygen at a red heat in a vacuum. That the phenomenon is one of oxidation is also shown by the fact that the heat of absorption per gram atom of oxygen (+187 K) is intermediate between the heats of formation of palladious and palladic hydroxides. Palladium black absorbs over 1,000 volumes of hydrogen, but part of this forms water with the oxygen originally present. The amount actually occluded was found to be 854 868 volumes, the greater part of which is removable by pumping at the ordinary temperature, and practically the whole at 444°. Palladium sponge absorbs 833 volumes of hydrogen, 99 per cent. of which can be pumped off at the ordinary temperature. Increasing the pressure up to 4·6 atmospheres does not influence the absorption. Palladium foil does not absorb hydrogen until it is converted into a spongy mass by repeated ignition ; the gas is easily expelled at 100° C. in a vacuum. The heat of absorption per gram of hydrogen is 46·4 K ; or, deducting the heat corresponding to the work done by the atmosphere, 43·7 K. This value differs greatly from that found for the heat of absorption by platinum black (66·1 K), from which it is inferred that occlusion does not consist simply in the liquefaction or condensation of the gas in the pores of the metals. The atomic ratio of palladium to hydrogen in

the fully charged metal ranges from 1·37 to 1·47, corresponding nearly with the formula Pd_3H_2; this appears, however, to be almost the only evidence there is for the existence of such a compound. N. L.

1205. *Solid Solutions.* **H. P. Cady.** (Journ. Phys. Chem. 3. pp. 127–136, 1899.)—Naphthalene and monochloracetic acid form two series of solid solutions, naphthalene being the main constituent of the one series and monochloracetic acid of the other. Liquid mixtures of the two substances are allowed to solidify partially at a suitable temperature, which is maintained constant for some hours until equilibrium between the solid and liquid phases is established. These are then separated and analysed. The following table contains the results (the meaning of which is, however, best seen from the curve representing them). The naphthalene melted at 79·9°, the acid at 62°; the numbers indicate molecules per 100 molecules of the mixture :—

NAPTHALENE SERIES.

	Solid Solution.		Liquid Solution.	
Temp.	Naphthalene.	Acid.	Naphthalene.	Acid.
75°	96·6	3·4	84·4	15·6
70°	95·4	4·6	67·7	32·3
65°	89·2	10·8	53·3	46·7
60°	80·3	19·7	42·4	57·6
55°	59·6	40·4	31·3	68·7
53·5°	—	—	29·4	70·0

ACID SERIES.

60°	1·7	98·3	4·0	96·0
55°	2·1	97·9	21·0	79·0

At the quadruple point (53°) a liquid solution, and two solid solutions of the following compositions are in equilibrium :—

Solid solutions { 43 napthalene, 57 acid.
2·5 „ 97·5 „

Liquid solution { 28·7 naphthalene.
71·3 acid.

Glycollic acid behaves in a similar way; acetic acid, and probably malonic and succinic acids, however, do not form solid solutions with naphthalene. T. E.

1206. *Explosive Properties of Acetylene.* **G. Claude.** (Comptes Rendus, 128. pp. 303–304, 1899.)—Under atmospheric pressure, at $-80°$, acetone dissolves more than 2,000 times its volume of acetylene. A platinum wire, heated to bright redness by an electric current, does not cause this solution to explode. Liquid acetylene itself at about $-80°$ and under a pressure of 1·3 atmospheres (its own vapour pressure) behaves in the same way.

T. E.

1207. *New Atmospheric Gases.* **W. Ramsay.** Mem. Manchester Lit. and Phil. Soc. 43. 4. pp. 1–19, 1899.)—A lucid account of the chief results of the author's researches and their bearing on the kinetic theory and on the periodic law. (See 1898, Abstract Nos. 1370 and 1371, and 1899, No. 841.) T. E.

1208. *Molecular Weight of Sulphur.* **H. T. Barnes.** (Journ. Phys. Chem. 3. pp. 156–159, 1899.)—The author endeavours to ascertain the molecular weight of sulphur in carbon disulphide solutions by means of empirical relations deduced from Pfeiffer's measurements of the densities of such solutions. F. G. D.

1209. *Determining Molecular and Atomic Weights.* **D. Berthelot.** (Journ. de Physique, 8. pp. 263–274, 1899.)—The author describes the method as being based on the law of Gay-Lussac and the Avogadro-Ampère principles. But the latter principle could be exact for different temperatures and different pressures only if all gases had the same compressibility and the same coefficient of expansion. But Regnault's experiments show that the coefficients of expansion of different gases (under constant pressure and constant volume) approximate more and more closely to a common value (about 1/273) as the pressure diminishes. Thus Gay-Lussac's laws are limiting laws, exact for very low pressures: under these conditions of extreme rarefaction the molecular volumes of all gases may be taken as exactly equal. The limiting density of a gas (under an infinitely small pressure) cannot be measured experimentally; but it can be deduced from its normal density (at 0° and atmospheric pressure) if the law of compressibility of the gas be known. The molecular weights of gases are then proportional to their limiting densities. The methods of calculation are described, use being made of the results and investigations of Regnault, Van der Waals, Amagat, Rayleigh, Leduc, and Sacerdote. The physical method gives the following atomic weights (oxygen = 16): hydrogen, 1·0075; carbon, 12·004; nitrogen, 14·005; sulphur, 32·050; argon, 39·882. The values for hydrogen and carbon agree excellently

with those obtained by the chemical method. In the case of nitrogen the latter method is indirect. Stas found N = 14·044; but other cycles of reactions give lower numbers, *e.g.*, 14·019 (Thomsen) and 14·012 (Hill). Stas's value for sulphur is S = 32·058. It is interesting to note the magnitude of the error that would arise in this case through taking the normal instead of the limiting density: the former would give S = 33·55. The value for chlorine given by the physical method (35·479) differs sensibly from that found by Stas (35·456). The former is based on the density of a single compound (HCl) prepared by a single method, and must therefore be regarded with reserve. D. E. J.

1210. *Solubility and Melting-point of Racemic Compounds and Inactive Mixtures.* **H. W. B. Roozeboom.** (Zeitschr. Phys. Chem. 28. pp. 494-517, 1899.)—Racemic compounds of two optically isomeric substances may be distinguished from simple mixtures or from crystals containing the two in isomorphous mixture (pseudo-racemic mixed crystals) by means of the solubility or the melting-point. In order to do this, however, it is necessary to study the whole curve of solubility or melting-point for mixtures containing the two isomers in all proportions. The typical curves for each case are given in the paper, and without them an abstract is of little use. The following results may, however, be mentioned. The determination of the composition of the three solutions saturated (*a*) with the inactive compound, (*b*) with the inactive and the dextro-, (*c*) with the inactive and the lævo-rotatory substances is sufficient in many cases to decide the nature of the inactive substance. If it is an ordinary mixture of the dextro- and lævo-rotatory compounds, all three solutions are identical and inactive; if it is a racemic compound the first solution is inactive, the second dextro-, and the third lævo-rotatory. The curve of the melting-points of mixtures of the two isomers consists of two parts melting at an angle when no racemic compound is formed; it consists of three branches melting at angles when a racemic compound exists, and, in all probability, forms only one continuous line when the two isomers form solid solutions. The melting-point of the racemic compound may be higher or lower than that of the active isomers, and the same is true of the pseudo-racemic mixed crystals; the melting-point of the ordinary inactive mixture of the two isomers is, however, always lower than that of the isomers alone.

At temperatures below the melting-point further transformations of the solid substances may take place. These also are considered. T. E.

1211. *Volumes of Aqueous Solutions.* **E. B. H. Wade.** (Journ. Chem. Soc. 75. pp. 254–277, 1899.)—The author describes an apparatus which enables a direct measurement to be made of

the change in volume which occurs when a certain volume of solution is diluted with an equal volume of water. It consists of a U tube, one arm of which originally contains a solution, whilst the other contains pure water. The U tube is terminated by fine tubes which enable changes of volume to be readily measured. In most cases the results can be represented by the empirical formula, $x = n^b/a$, where x is the contraction on 100,000 cc. of solution and water combined, n the number of gramme equivalents of dissolved substance in 100,000 cc. of mixture, and a, b, are constants. Some of the results obtained are given below, the temperature being 18°–20° C.

	KCl	NaCl	$SrCl_2$	$CaCl_2$	Cane Sugar	LiCl	HCl
a	19·1	25·0	12·59	13·275	57·15	19·28	29.45
b	1·64	1·70	1·54	1·52	2·00	1·528	1·49

The results can also, in general, be expressed by the empirical equation

$$\phi = \text{constant} + \frac{n^{b-1}}{a(2^{b-1}-1)}$$

where ϕ is the apparent volume of one gramme equivalent of the dissolved substance after 50 per cent. dilution. A. Gs.

1212. *Photoelectric Currents.* **G. C. Schmidt.** (Wied. Annalen, 67. 3. pp. 563–577, 1899.)—The substance used by the author for producing photoelectric currents is not one of the highly sensitive silver halogens, but cupric oxide, which under the influence of light is transformed into the well-known and well-defined cuprous oxide. He immersed two plates of electrolytic copper in a normal $CuSO_4$ solution. A deflection of 13 mm. was obtained on immersion, and this increased by 5 mm. in one minute on illuminating one of the electrodes. Similar results were obtained in the case of zinc and lead, but it was always noticed that the purer the metal the less was the photoelectric effect. The author concludes that light is incapable of producing an E.M.F. at the surface of absolutely pure metals. Whatever effects are observed are probably due to a diminution of the polarisation, or to a special influence upon the gases occluded in the metal. Under the influence of light, CuO and Cu_2O undergo a slow transformation, which reduces their potential. At low potentials, cupric oxide becomes positive under the influence of light. This means that the solution pressure of the oxygen is raised. At high potentials CuO becomes positive in red light and negative in violet light. In the first case, the light raises the solution pressure of the oxygen, while in the second case it transforms the salt into the low-potential modification. E. E. F.

1213. *Electrochemical Theory, III.* **R. Mewes.** (Elektrochem. Ztschr. 5. pp. 217–223, 1899. See 1898, Abstract No. 673.)—The author continues his speculations, and claims to establish a relationship, which holds good for the gaseous, liquid, and solid states, between the refractive power of a compound and that of its constituent elements. N. L.

1214. *Neutralisation.* **G. Platner.** (Elektrochem. Ztschr. 5. pp. 199–201, 1899.)—The author discusses the thermal aspect of a number of chemical reactions, and endeavours to show that the heat of neutralisation is due, not, as supposed by Ostwald, to the combination of the hydrogen of the acid with the hydroxyl of the base, but to a loose union of acid and base. Various arguments are also brought forward in support of the theory of hydrolytic, as opposed to ionic, dissociation. N. L.

1215. *Determinations of Constitution by the Electrometer.* **R. Kieseritzky.** (Zeitschr. Phys. Chem. 28. pp. 385–423, 1899.)—The author measures the potential difference between mercury and various solutions containing organic mercury salts. The measurements are carried out in the usual way, with a subsidiary calomel electrode and a Lippmann electrometer. The potential difference thus determined serves as an index to the degree of electrolytic dissociation of the salt. The author shows that if the hydrogen replaced by the mercury is *amidic*, the dissociation is less than if it is *carboxylic*. If the replaced hydrogen is *imidic*, then the dissociation is still smaller.

The author concludes (1) that hydrocyanic acid is an *imide* compound; (2) that mercury, silver, and alkali succinimides contain the metal directly combined with nitrogen; (3) that nitrous acid is an *imide* compound, its salts and esters having the formula $R-NO_2$.

These conclusions are founded on the feeble dissociation of the corresponding mercury compounds in aqueous solution.

The paper contains further a presentation of the author's views on the subjects of isomerism of nitrogen compounds and tautomerism. F. G. D.

1216. *Freezing-points of Ternary Mixtures.* **J. Waddell.** (Journ. Phys. Chem. 3. pp. 160–164, 1899.)—"If the components of a binary solution be A and B, of which A is the one separating as solid phase, the addition of a third substance, C, slightly miscible with A and readily miscible with B, might be expected to lower the freezing-point till a certain quantity of it was added, and then to cause a rise in the temperature of freezing."

With the object of verifying this, the author has carried out a series of freezing-point determinations where A = water, B = acetone, and C = salicylic acid, phenol, paranitrophenol, hydroquinone, or ether. All the substances mentioned under C, except ether, caused either no change or a rise in the freezing-point. With ether a depression was obtained, but the phenomenon was complicated in this case by the appearance of two liquid phases. F. G. D.

1217. *Demonstration of the Phase Rule.* **P. Saurel.** (Journ. Phys. Chem. 3. pp. 69–71, 1899.)—From the well-known equation:—

$$\eta\, dt - v\, dp + m_1\, d\mu_1 + \ldots + m_n\, d\mu_n = 0,$$

Gibbs concludes that there exists an integral relation between p, t, $\mu_1 \ldots \mu_n$. The author states that this conclusion is unwarranted but *correct*, and proceeds to supply the missing links. F. G. D.

1218. *Demonstration of the Phase Rule.* **P. Saurel.** (Journ. Phys. Chem. 3. pp. 137–143, 1899.)—The author gives a proof of this theorem which, he states, is both short and complete. The various demonstrations in existence are described as being either long or incomplete. The author's discussion is certainly lucid and in some respects novel, but it is not short enough for reproduction in an abstract. (See also preceding Abstract.) F. G. D.

1219. *Equilibrium of Stereoisomers, III.* **W. D. Bancroft.** (Journ. Phys. Chem. 3. pp. 144–155, 1899.) — The author discusses by means of his triangular diagram the various possible equilibria which may occur in the case of two mutually convertible (*i.e.*, *tautomeric*) isomers in presence of a third substance which may form solid compounds with the former. The discussion is based on the Phase Rule and Duhem's theory of the "*curve of natural state.*" No experimental results are given, but some illustrative examples are quoted from the oximes. It is shown how the relative stability of the isomers and their compounds may be predicted from the diagram, and how the relative stability may become reversed in the latter case. F. G. D.

1220. *Mutual Solubility: Vapour Pressure and Critical Points of Mixtures.* **J. P. Kuenen** and **W. G. Robson.** (Zeitschr. Phys. Chem. 28. pp. 342–365, 1899.)—The equilibrium of two substances in the liquid state and that of vapour, which as

liquids are not miscible in all proportions at all temperatures, is investigated, especially in regard to the equilibrium-pressure.

If p_1, p_2, p denote the vapour pressures of two such liquids when separate and mixed ($p_1 > p_2$), the old law gave $p > p_1$ or p_2. Konowalow, however, showed theoretically that the case $p_1 > p > p_2$ is possible, and Bakhuis-Roozeboom discovered a pair, sulphur dioxide and water, which conforms to this law.

In most cases, rise of temperature causes increase of the mutual solubility until the two liquid phases become identical, after which there is perfect miscibility in all proportions. In other cases a similar action is produced by fall of temperature, and in a third series of cases both these actions are traceable. Rothmund therefore suggested that the diagrammatic solubility-curve for every pair of liquids is closed, and has two points upon it corresponding to two critical points of perfect miscibility.

The authors point out that another case may occur wherein the vapour and the lighter liquid phase become identical before the two liquid phases do so ; beyond this point, therefore, two phases alone coexist, and their composition and density must depend on the pressure as well as on the temperature, and consequently on the ratio of the amounts of the two liquids which are initially put together, so that a solubility-curve proper exists only below the critical point for the vapour and the lighter mixture and above that for the two liquid phases; and in this case it is not closed. Mixtures wherein these two critical points have been observed are those of ethane with ethyl-, propyl-, isopropyl- and butyl-alcohols: for ether and water, and also for ethane and methylalcohol, only the vapour-lighter mixture critical point has been realised.

The paper gives these interesting observations in detail.

R. E. B.

1221. *Solidification of Liquid Mixtures of Tautomeric Substances.* **H. W. B. Roozeboom.** (Zeitschr. Phys. Chem. 28. pp. 289–301, 1899.)—The author begins by emphasising the now well-known fact that the number of components in a system depends practically on the *speed* with which possible reactions in the system take place. Defining *tautomeric* substances in the modern way as isomers—structural, geometrical, or optical—between which a more or less slow reversible transformation occurs, the author proceeds to discuss how *temperature*, as influencing the speed of transformation, may modify the conditions of the system. At higher temperatures we have comparatively rapid mutual transformation in liquids, and so are dealing with *one-component* systems. Employing a temperature-concentration diagram, we get for such temperatures a single "equilibrium-curve." If we assume that for temperatures in the neighbourhood of or below the freezing-points of the pure isomers, the speed of transformation has become practically zero, then at such temperatures the system contains two components, and we have the

ordinary diagram, *i.e.*, either the two intersecting *freezing-point* curves for the two isomers, or these separated by an intermediate curve, according as a solid compound does not, or does, exist under the given conditions. Between these regions of comparatively high and comparatively low temperature, where we have either mutual transformation (resulting in a state of equilibrium which is a single-valued function of the temperature) or complete indifference respectively, Roozeboom assumes, following the example of Duhem, the existence of a region of "*false equilibrium*." In this region the single equilibrium-curve bifurcates, and the state of equilibrium ceases to be a single-valued function of the temperature. The equilibrium reached depends on which isomer one started out with.

By means of the diagram so obtained the peculiar phenomena observed in the solidification of a melted tautomer become at once evident. The various possibilities are discussed in detail by Roozeboom, and it is shown in what way the freezing-point of the melt is dependent on the temperature to which it has been raised, the length of time it has been heated, and the manner of its cooling. F. G. D.

1222. *Dissociation Studies, I.* **W. D. Bancroft.** (Journ. Phys. Chem. 3. pp. 72–94, 1899.)—In this paper the author studies two-component systems in which a compound exists which undergoes slow dissociation in the liquid and vapour phases. In the first place a concentration-temperature diagram is employed, and it is shown how the compound may exhibit melting-points varying between certain definite limits, according to the rapidity of heating and the speed of dissociation in the liquid. Orthophthalic acid is quoted as an example, and the varying results obtained by different investigators explained by the above theory. It is shown that its stable melting-point (*i.e.*, the melting-point corresponding to complete equilibrium in the melt) is 184° C., and that phthalic acid and its anhydride apparently form solid solutions.

The author then goes on to consider pressure-temperature diagrams in which the partial-pressure curves are shown, and a discussion of this form of diagram leads easily to a demonstration of the existence under certain conditions of Van der Waal's "*maximum temperature of sublimation*" for a subliming compound which dissociates into two *volatile* components. This temperature is the highest temperature at which the solid compound will sublime *en masse*, *i.e.*, volatilise without giving rise to a liquid or a new solid phase. By interpolation the author calculates the maximum sublimation temperature for iodine monochloride and finds it to be $24° \pm 1°$.

By considering the influence of time when the rate of dissociation in the vapour is slow, the author shows that for a given temperature the pressure corresponding to comparatively rapid

volatilisation should be lower than the equilibrium-pressure, and he further shows that a raising of the melting-point by volatilisation under diminished pressure can be similarly explained. In this way the remarkable results obtained by Ramsay and Young with aldehyde-ammonia and chloral hydrate find their explanation. In conclusion the author discusses the phenomenon observed by Ramsay and Young in the case of phthalic acid, and more especially succinic acid, viz., that the static sublimation-pressure is higher the greater the amount of acid taken. It is shown that this curious result may be explained by assuming that the anhydrides form isomorphous mixtures with the acids. F. G. D.

1223. *Osmotic Work and Pressure.* **A. A. Noyes.** (Zeitschr. Phys. Chem. 28. pp. 220–224, 1899.)—In a previous paper the author obtained a relation between the osmotic pressure and the osmotic work, and hence deduced a value for the volume factor of the latter which is given by the equation $dv = v_o/(1 + Pk/2)$, where P is the osmotic pressure, k the coefficient of compressibility of the solvent, and dv the alteration in volume produced when a volume, v_o, of the solvent is added to the solution, the concentration being assumed to be constant. This volume alteration cannot be obtained experimentally, since if water is added to even an infinite volume of solution the volume change may be finite, and the concentration altered, although the alteration in pressure is infinitely small. Dieterici's calculations of osmotic pressure from the alterations of density with concentration are rendered invalid through neglect of this consideration, and it is shown that the volume alterations deduced by Dieterici are not in agreement with the values calculated from the formula given by the author. N. L.

1224. *Osmotic Pressure.* **F. Barmwater.** (Zeitschr. Phys. Chem. 28. pp. 115–144, 1899.)—The author criticises the application of the kinetic theory of gases to solutions, and frames a rival theory, in which the molecules of the solute have no freedom beyond that characteristic of ordinary liquid molecules. He proposes to verify it by measurements of the changes of volume and temperature attending dilution. E. E. F.

1225. *Osmotic Wind.* **K. Schreber.** (Zeitschr. Phys. Chem. 28. pp. 79–95, 1899.)—When air is in bodily motion, the mean squares of the molecules in three co-ordinate directions have different values. By suitably choosing the co-ordinates, two components can be made equal, while the excess of the third represents the velocity of the wind. Since the kinetic theory of gases has

been applied to the theory of solutions, it is interesting to look for an analogy with atmospheric wind. Such an analogy holds good in the case of electrolytes under the influence of a current. If an aqueous solution of $Cu(NO_3)_2$ is divided into two portions by a diaphragm of copper ferro-cyanide, the latter is exposed on both sides to the impact of Cu molecules, to which it is impermeable. On passing a current through the solution the impacts are increased on one side and diminished on the other, thereby producing a difference of osmotic pressure analogous to wind. The author places this in evidence by experiments with Pfeffer cells, compensating the osmotic wind by hydrostatic pressure. He points out a fundamental difference between the phenomenon described and that of electric osmose. For a minute aperture in the thin membrane used cannot be regarded as a tube, and the membrane itself is a perfect metallic conductor. There is a proportionality between potential difference and osmotic wind pressure which does not at all agree with the kinetic theory as applied to solutions. E. E. F.

1226. *Drop Electrodes.* **W. Palmaer.** (Zeitschr. Phys. Chem. 28. pp. 257–279, 1899.)—The changes of concentration attending the contact between a metal and an electrolyte are placed in evidence by purely chemical means, without closing an external circuit. The author employs a new kind of mercury dropper, consisting of a vessel opening downwards and closed by a glass stopper having about 100 channels etched into its circumference, giving rise to as many trains of droplets. The mercury is passed out under a pressure of 5 atmospheres. The drops fall through a solution of 0·0005 – normal mercurous nitrate, in which they produce considerable differences of concentration. These are made evident by SH_2 water and indigo. This is the first purely chemical proof furnished of the transfer of ions under such conditions. The experiments confirm Nernst's theory of electrolytic solution-pressure, of which they are a simple and direct consequence. At the same time, the results bring no evidence tending to discredit Warburg's theory of electrocapillary phenomena. E. E. F.

1227. *Concentration Cells with Insoluble Electrodes.* **K. Schaum.** (Zeitschr. Elektrochem. 5. pp. 316–319, 1899.) — The cells considered have platinum electrodes immersed in solutions containing a mixture of an oxidising agent and the product formed by its reduction, for example, a ferric and a ferrous salt or a ferri- and a ferro-cyanide. Calling C_1 and C_2 the concentrations of the ferri- and ferro-cyanide ions in the one solution, C_1' and C_2' their concentrations in the other, and n the difference in the number of charges carried by the two kinds of ions, the

E.M.F. of the cell is, according to Nernst's osmotic theory, given by the equation—

$$E = \frac{RT}{n\varepsilon} \log \frac{C_1 C_2'}{C_2 C_1'}$$

Experiments made with solutions of ferri- and ferro-cyanides are in good agreement with this formula. T. E.

1228. *E.M.F. of Concentration Cells.* **J. E. Trevor.** (Journ. Phys. Chem. 3. pp. 95–106, 1899.)—The author shows that the E.M.F. of a concentration cell is proportional to the absolute temperature only when the heat of dilution from one concentration to the other is negligibly small, and that if this latter condition be not fulfilled, the deviation from proportionality is determined by the *form* of the heat of dilution regarded as a function of the temperature and the concentrations of the two solutions of the cell.

If E=E.M.F. of cell, h_1, h_2=concentrations, Δ=heat of dilution between h_1 and h_2, Θ=thermodynamic temperature, then

$$E = \Theta . K(h_1, h_2) + \Theta . F(\Theta, h_1, h_2),$$

where

$$\frac{\partial F}{\partial \Theta} = -\frac{\Delta}{\Theta^2}.$$

F. G. D.

1229. *Ionisation of Polyvalent Salts.* **P. Calame.** (Zeitschr. Phys. Chem. 27. pp. 401–420, 1898.)—The freezing-point method was for the most part used in this research. It was thus found that copper malate in aqueous solution formed complex molecules, in which probably copper was substituted for the H of the hydroxyl group. The copper salts of citric and glyceric acids, but not those of salicylic and lactic acids (which also contain hydroxyl groups), form similar complex molecules. Magnesium fumarate is more strongly dissociated than the maleate, a fact which may find its explanation in the ionisation of the salts in different successive stages. W. G. M.

1230. *Law of Dilution of Electrolytes.* **T. P. Muller.** (Comptes Rendus, 128. pp. 505–507, 1899.—According to Ostwald, the molecular conductivity of a solution containing a gramme-molecule of a normal salt in v litres is given by the equation $\mu = \mu_\infty - \delta$, where δ is a function of v alone, provided the temperature is constant. A similar dilution law has recently been applied by Kohlrausch to the mobility of the ions themselves (see 1899, Abstract No. 331). On examining the results obtained by Kohlrausch and also by Bredig, it is seen that in a

series of experiments in which the dilution is successively doubled the values of $\hat{c}$ form a geometrical progression with a common ratio of $\frac{1}{2}$. Hence it is shown that the molecular conductivity of a solution of a normal salt containing monovalent radicles is given at 18° by the equation $\mu=\mu_\infty-52{\cdot}72v^{-0{\cdot}471504}$ and at 25° by $\mu=\mu_\infty-62{\cdot}152v^{-0{\cdot}471504}$. N. L.

1231. *Influence of a Binary Electrolyte on the Solubility of a Ternary Electrolyte with Different Ions.* **A. A. Noyes** and **E. S. Chapin.** (Zeitschr. Phys. Chem. 28. pp. 518-522, 1899.)—Calcium hydroxide is more soluble in solutions of ammonium chloride than in pure water, owing to the formation of calcium chloride and ammonia. The solubility in a case of this kind is readily calculated when the ionisation of the different salts in the solution is known. The degree of dissociation of the calcium hydroxide in saturated aqueous solution, at 25°, is found to be 0·808. The results obtained at 25° are the following, the unit of concentration used being 0·001 gram molecule per litre :—

Concentration of the Ammonium Chloride.	Solubility of the Calcium Hydroxide.	
	Found.	Calculated.
0	20·22	...
21·76	29·08	28·9
43·52	39·23	38·6
87·03	59·68	58·3

T. E.

1232. *Conductivity of Mixed Electrolytes.* **F. Barmwater.** (Zeitschr. Phys. Chem. 28. pp. 424–430, 1899.)—The author extends to the case of a mixture of electrolytes a theory developed by him (Zeit. Phys. Chem. 28. p. 131 *et seq.*) for one electrolyte. He measures the conductivities of various mixtures, namely, NaCl and KCl; NaCl and KI; NaCl and KNO_3; KCl and KNO_3; NaCl, KCl, and KNO_3; NaCl, KCl, KNO_3 and KI, and finds a good agreement between the results so obtained and those calculated from his formulæ. F. G. D.

1233. *Electrolytic Conductivity.* **R. Abegg.** (Zeitschr. Elektrochem. 5. pp. 353 355, 1899.) -The connection is pointed out between the general conditions affecting electrolytic conductivity and the fact that pure, simple liquids are practically non-conductors. In order that a liquid may be a conducto

it is necessary that a substance should be present which, from its chemical constitution, is capable of furnishing ions, and that the production of the latter should be favoured by the presence of a medium having a high dielectric constant. It is also important that the electrolyte should exist in the form of directly dissociable, simple molecules, and not of complex, polymerised molecules which must undergo preliminary decomposition before ions can be formed. In the case of most liquids, however, high specific inductive capacity is associated with a high degree of polymerisation, the only exceptions being nitrobenzene, ethylic nitrate, and benzonitrile; and these liquids, from their chemical nature, are unsuited for the formation of ions. The only class of pure substances which are good electrolytes is that including fused salts, where all three conditions appear to be favourable. Little is known of the molecular state of these substances, but judging from analogy their dielectric coefficients are probably high, and they are eminently suited for the formation of ions. It is calculated that in fused silver chloride the concentration of the free ions is about 10^{-2} normal, whereas with water it is only about 10^{-7} normal. Another factor, besides those already mentioned, in the production of electrolytic dissociation is the power of the ions to associate themselves with molecules of the solvent, as is shown by the high conductivity exhibited by solutions of salts in liquid ammonia. N. L.

1234. *Influence of Membranes on Ionic Migration.* **W. Bein.** (Zeitschr. Phys. Chem. 28. pp. 439–452, 1899.)—Determinations of the relative velocity of the ions of a salt give different results according as they are made with or without membranes. The results also depend on the kind of membrane used. A comparison of results obtained without any membrane with those obtained with membranes shows that the effect of the latter is to diminish the relative velocity of the kathion. Diaphragms of parchment paper or of porous earthenware have the smallest, those of goldbeater's skin or animal membranes the largest effect. The author concludes that the phenomena may be ascribed either to the membrane possessing the character of an acid and combining with some of the kathions, or to polarisation of the membrane, which would result in the (possibly temporary) deposition of the kathions upon it. T. E.

1235. *Limiting Values of E.M.F. for Electrolysis.* **E. Bose.** (Zeitschr. Elektrochem. 5. pp. 154–177, 1898.)—The apparatus used and the manner of making the observations are fully described. It is found that the estimation of the decomposition values can be best determined with the aid of a continually

increasing potential, and with the smallest possible current intensity. The divergence of the curves from the theoretical form is explained by alterations in concentration. The separation of solid deposits affords very sharp indications of the decomposition points, whilst the separation of soluble bodies, especially of gases, gives indeterminate points. Copper salts show two characteristic kathode decomposition points, of which the first is probably to be assigned to the ions Cu^{+}-Cu^{+}. An O_2-electrode is strongly depolarised in solutions of mercurous salts. Silver separates from nitric acid solution as Ag^{+} ion. Acids usually show as many characteristic decomposition points as there are ions produced by gradual dissociation. W. G. M.

1236. *Electrolytic Reduction of Meta-nitro-toluene.* **A. Rohde.** (Zeitschr. Elektrochem. 5. pp. 322–324, 1899.)—Meta-nitrotoluene is readily reduced by electrolysis in the way described by Elbs and Kopp (Zeitschr. Elektrochem. 5. p. 108, 1899). The first product is *m*-azotoluene, which on further reduction yields *m*-hydrazotoluene, the current efficiencies being 91 and 70 per cent. respectively. T. E.

1237. *Electrolytic Estimation of Lead.* **A. Hollard.** (Électricien, 17. pp. 84–86, 1899.)—The author considers the literature of this subject is lacking in details. As under correct conditions the determination of lead as peroxide by electrolysis is simple and reliable, he publishes the methods of procedure used by himself—for various metals and alloys containing lead. The quantity of lead to be separated should not exceed ·2 gram. A platinum cone should be used as anode, and a platinum spiral as kathode. The cone should be roughened before use by immersion in aqua regia. The correct dimensions of cone and spiral are given. A glass beaker is used to contain the electrolyte, and the solution of the metal or alloy is effected in this same beaker. The deposit of lead peroxide on the anode, after washing by immersion, must be maintained for at least fifteen minutes at a temperature of 200° C. before weighing, in order to obtain the definite compound PbO_2. Detailed instructions for the application of the method to the determination of lead in the following metals and alloys are then given: 1. Pure lead. 2. Commercial zinc. 3. Commercial tin and lead-tin alloys. 4. Commercial antimony and lead-antimony alloys. 5. Commercial copper and bronzes.

It is found that the proportion of free nitric acid required in the electrolyte depends upon the presence or absence of copper. The author explains this by the theory that when copper is present the copper nitrate supplies a portion of the oxygen necessary to form PbO_2 on the anode, while when copper is absent the

whole of this oxygen has to be provided by the nitric acid. In the latter case, therefore, a larger amount of free nitric acid has to be added at the commencement of the deposition.

J. B. C. K.

1238. *Electrolytic Sodium Pertungstate.* **G. E. Thomas.** (Indus. and Iron. 26. pp. 327–328, and 369–370, 1899.)—In the course of the investigation on the atomic mass of tungsten the author has studied the behaviour of sodium tungstate when submitted to electrolysis, and found that a gas was evolved which liberated iodine from potassium iodide solution. The apparatus employed consisted of a bulb with two openings, the lower aperture being covered with a parchment diaphragm. The bulb was placed in a beaker, the latter having a kathode of platinum or other metal, the platinum anode being placed inside the bulb. The solution employed consisted of 15 gr. sodium tungstate in 50 cc. of water and ½ cc. acetic acid. The current was 1·4 amperes at 107 volts. Conversion of the salt into the para condition takes place, and the solution acquires a yellow colour round the kathode. When no precipitate is produced on the addition of nitric acid after six hours the operation is stopped. On evaporation of the yellow solution below 100° C., a crop of yellowish white crystals was obtained, which, however, only consisted of a partially peroxidised salt. Various attempts to purify the salt thus obtained failed to give satisfactory results, nor did alteration in the electrolytic conditions produce a purer product. Pertungstate of soda on heating liberates ozone.

O. J. S.

1239. *Electrolytic Chlorates, Bromates, Iodates, and Hypochlorites.* **W. Waubel.** (Ind. Electrochem. 3. pp. 14–15, 1899.)—The author has found that by use of a diaphragm and of an anode solution of sodium bicarbonate, the whole of the chlorine carried into the anode chamber can be converted into chlorate. The electrolyte should be kept at 60°–70° C., the current density should be 5 to 10 amperes per sq. decimetre, and the E.M.F. should be 4 to 5 volts. The solutions of bicarbonate for the anode chamber and of chloride for the kathode chamber should be saturated. In order to maintain the former in this state, additions of fresh amounts of bicarbonate are necessary from time to time. In the anode chamber 6½ grammes of chlorate are obtained for every 7½ grammes of bicarbonate used, while in the kathode chamber a 10 per cent. solution of sodium hydrate can be obtained.

Comparing the electrical energy necessary to produce chlorate by this process with that required in the experiments of Oettel

and of Gall and Montlaur, the following comparative figures are obtained :—

Oettel.....	Alkaline electrolyte without diaphragm.....	736	Watt hrs. yield	88·14 grms
Gall & Montlaur	Alkaline electrolyte with a diaphragm.....	1003	,,	,,
Waubel.....	Bicarbonate in anode chamber with a diaphragm.....	951	,,	,,

The latter process has the advantage over the other two, that sodium hydrate is concurrently produced, and can be recovered from the kathode solution.

Bromates and iodates can be obtained by a similar method of procedure. By operating at a low temperature hypochlorites can be produced. Potassium ferro-cyanide and chromous hydrate can be raised to the higher stage of oxidation by placing them in the anode compartment of a similar cell. The attempts to produce fluorates by this method have not yet resulted in success.

J. B. C. K.

1240. *Electrolytic Extraction of Mercury.* (Ind. Électrochim. 3. pp. 6–7, 1899.)—Cinnabar, the naturally occurring sulphide of mercury, is crushed to a fine state of sub-division, and is then treated with a hot solution of sodium sulphide containing sodium hydrate. The extracting vessels should be worked in series. The electrolytic vats are of iron, and may be used as kathodes. The anodes should be of sheet-steel. Using a current density of 0·5 to 0·8 ampere per sq. decimetre, and an E.M.F. of 2 volts, the mercury can be separated from the sulphide solution without difficulty. The electrolyte can be used again for extracting fresh ore after addition of sulphur. J. B. C. K.

1241. *Electroplating the Hulls of Vessels.* (Elect. Engin. N.Y. 27. pp. 131–132, 1899.)—After a series of tests covering a period of four years, a favourable report has been rendered to the United States Government on T. S .Crane's system of copper-plating the hulls of vessels. The ocean-going tug *Assistance* was electroplated and launched in February, 1895. A short time ago she was docked and subjected to a critical examination ; her bottom was absolutely free from marine growth of any kind.

The method of electroplating consists primarily in the use of flexible shallow baths, open at one side, and being made water-tight by suitable flexible packing at the edges. The baths are made flexible in order to follow the curvature of the vessel, and are supported against its side or bottom by tension ropes, screw shores, or magnets. The vessel forms the negative pole, the plating bath the positive ; the plating is done in sections which slightly overlap, so as to form a continuous coating. In order

that the density of the solution may be kept uniform, circulation is effected by letting the solution flow into the bottom, and out near the top, of the bath. A current rate of $7\frac{1}{2}$ amperes per square foot and a potential difference of $1\frac{1}{2}$ volts give a uniform, smooth, and adherent coating to the metallic surface of the vessel.

The whole bottom of a ship 400 feet long, drawing 20 feet of water, can be plated in eight or nine days, using about 55,500 pounds of copper. The tests were conducted by the well-known electrical engineer, A. A. Knudson, and the electro-chemist, W. J. Comly. The former says in concluding his report: "I have discovered so far nothing about this boat that could be considered as a serious objection to this method of copper-plating the bottom of an iron or steel vessel, and I believe this invention will have a very important future. I suggest that not less than one-sixteenth of an inch of copper plating should be allowed."

It is claimed that as much as £4,000 per annum is expended by various ships in the trans-Atlantic trade to overcome the added friction caused by fouling, while the cost of docking a big ship twice a year would nearly double the total loss as a penalty for unprotected bottoms. An iron vessel with a speed of 20 knots, if coated with copper, will have, it is calculated, a speed of 21 knots. A. S.

1242. *Electrolytic Vats.* **H. Becker.** (Ind. Électrochim. 3. pp. 13–14, 1899.)—A continuation of the notes previously dealt with (see 1899, Abstract No. 873). Vats in which mercury is used as kathode material in addition to those previously named, have been patented by Sinding Larsen, Kellner, Richardson, Vautin, Drake, Rosenbaum, Stoermer, Aret, Bell, Rhodin, and others. The author gives brief details of Kellner's German Patent 73224, and Kellner's English Patent 13722, of 1893, both designed to utilise the energy of the amalgam formed in the mercury cell.

Electrolysers for the production of the metal sodium in the pure state, or one of its alloys, are next described. Of this type are the electrolysers of Burghardt (12977, 1892), Grabau, Vautin (13568 and 20404, 1893) and Hulin. J. B. C. K.

1243. *Castner-Kellner Alkali Works.* **J. B. C. Kershaw.** (Elect. Rev. 44. pp. 509–513, 1899.)—This paper gives a history of the Castner-Kellner alkali process, together with some useful comparisons of the efficiency and cost of production of alkali and bleach by different methods.

After briefly describing the old Le Blanc process, the author gives a full account, with diagrams, of a Castner-Kellner cell. (See also 1898, Abstract No. 962.)

The plant already in use at Weston Point is of 2,000 H.P. capacity, whilst an extension of like size is in course of erection

With reference to the figures, no fresh information has been obtainable, but it is pointed out that the whole bleach output of the works has been sold until 1900 on very favourable terms, nearly thirty shillings higher than the current market price. Until, therefore, the old and new systems are competing on the same basis, it is difficult to gauge the exact additional profit which is realised by the electrolytic method. J. L. F. V.

1244. *Roberts' Electric Furnace.* (Zeitschr. Elektrochem. 5. pp. 340–342, 1899.)—The form of furnace protected by German Patent No. 100476, of July 28, 1897, is described at length. It is primarily intended for the manufacture of calcium carbide, but may obviously be used also for other purposes. In brief, the furnace consists of a rectangular vessel of sheet iron, with a hopper at one end of the cover and a flue at the other. The floor of the chamber consists of the upper side of an endless band of wire gauze, which is made to travel over roller supports by being stretched around a rotating drum at either end. The gauze is protected by a layer of asbestos. The carbon rods forming the electrodes are so pivoted at the hopper end of the furnace that they are free to move in a horizontal plane about their vertical axes. They may thus converge within the furnace so that their extremities are in contact, or they may be placed parallel, or of course at any intermediate angle of inclination. They are insulated from the end wall of the furnace through which they pass. In use, the carbon rods are first made to touch, a current is passed, the rods are then separated, and an arc is formed. Meanwhile the charge of powdered lime and carbon is fed through the hopper, carbide is formed between the poles, the current density is increased, the carbons are separated still further, and so on, until the rods are parallel and the arc is passing across the whole space between their ends. The gauze belt is kept in motion in such a direction that the charge from the hopper is conveyed to the zone heated by the arc. The carbide is thus removed as fast as it is formed, and fresh raw charge takes its place. As the carbide is formed and fused only in the zone between the ends of the electrodes, there are left layers of unaltered charge above and below it, the carbide itself forming a continuous cake. This cake is moved steadily forward with the rest of the charge to the cool end of the furnace, where it is broken up, and the unaltered mixture, in the pulverulent condition, is collected separately and again conveyed to the charging hopper. A modification of the furnace is described. W. G. M.

GENERAL ELECTRICAL ENGINEERING.

1245. *Pescetto Accumulators.* (Elect. Rev. 44. pp. 625–626 and 671–672, 1899.)—Three forms of this accumulator are constructed, suitable for lighting, for the distribution of electric energy, and for traction purposes respectively; and a *résumé* is given of the performance of the various batteries, which appear to be very efficient, under different conditions as regards rate and time of discharge. The grid is composed of an alloy of lead, which is said to be unattacked by sulphuric acid, and a superior physical condition of the active oxides is brought about by admixture with a substance, here termed *ulmate of ulmin*, which is obtained by the action of boiling dilute sulphuric acid on sugars. (See also 1898, Abstract No. 431.) N. L.

1246. *Accumulators for Motor-Cars.* **J. Reyval.** (Écl. Électr. 18. pp. 86–88, 1899.)—A detailed description, in tabular form, of five types of the Pisca accumulator. The specific constants of the larger types, per kilogram of total weight, are: capacity, 6·6 ampere-hours; energy, 12·6 watt-hours; power, 4·2 watts. The normal discharge is 2·2 amperes per kilogram for three hours, the E.M.F. 1·9 volts, and the specific weight 234 kilograms per kilowatt or 78 kilograms per kilowatt-hour. N. L.

1247. *Accumulator Switch.* **H. Müller.** (Elektrotechn. Ztschr. 20. pp. 152–154, 1899.)—The switch here described and fully illustrated is designed to carry 1,800 amperes. The "charge" and "discharge" sections each comprise a carriage actuated by a feed-screw and bearing two double-brush bridges. One of these bridges connects the accumulator terminals with a longitudinal contact-bar having teeth which extend between successive terminals and are equal in width thereto. The other bridge connects a similar parallel set of terminals and contact-bar, which is so arranged that its accumulator terminals are opposite to the teeth on the first-mentioned contact-bar. The second contact-bar is connected to the other bar and to the dynamo, or to the line, through a suitable resistance, to prevent short circuiting of the cells during regulation. Auxiliary switches actuated by spur-gearing from the feed-screws serve to break the circuit of each cell, as it is cut out of circuit, before the main bridge-piece has left the terminal of the cell; by this means sparking is confined to the auxiliary switches, and the life of the main switch is thus rendered practically unlimited. C. K. F.

1248. *A New Condenser.* (Elect. Engin. N.Y. 27. p. 134, 1899.)—This is a description of a condenser invented by C. S. Bradley, of Avon, N.Y. In its construction two conducting wires are wound on a bobbin, preferably arranged in alternate layers, one of the wires being covered with thread having a comparatively low specific inductive capacity, the several convolutions of which are separated from one another so as to leave open spaces between them : the other wire is bare. The wires may be coated, before winding, with the material which is to constitute the dielectric of the condenser, steareate of lead, and afterwards immersed in a hot bath of the same. The ends of the covered conductor are connected to one terminal, and those of the bare wire to a second one ; these form the terminals of the condenser. On the same general principle it may be formed of a plurality of wires wound in close relation, so as to lie adjacent to one another, one of the wires being wound with an open spiral of insulating material to form a spacing medium which will prevent mechanical contact of the two metallic surfaces with one another. W. G. R.

1249. *Electricity in a Medical Clinic.* (Amer. Electn. 11. pp. 57–62, 1899.)—This is a description of the electrical plant at the Polhemus Memorial Clinic, Brooklyn, N.Y., where electricity is used for various medical purposes as well as for working the ventilating fans. W. G. R.

1250. *Mechanical Applications of Electricity.* **G. Richard.** (Écl. Électr. 18. pp. 281–290, 1899.)—This is an illustrated descriptive article on electrically controlled railway signals and clocks. W. G. R.

1251. *Relative Merits of Glass and Porcelain as Insulators.* **A. Fleury.** (Électricien, 17. pp. 118–121, 1899.)—Hitherto porcelain insulators have been almost exclusively used for aerial conductors, on account of the well-known hygroscopic nature of glass. Recently, however, attempts have been made to produce insulators of a coarse kind of glass—the exact composition of which is a manufacturer's secret—which do not condense any film of moisture on their surface. Experiments carried out with such insulators appear to show conclusively that they are much superior to porcelain ; the author believes that they have a large field of usefulness before them. A. H.

1252. *Maxim's Method of Making Incandescent Lamp Filaments.* (Elect. Engin. N.Y. 27 pp. 174–175, 1899 ; U.S.

Patent No. 618704.)—In order to increase the resistance of incandescent lamp filaments for high-voltage lamps, H. S. Maxim mixes with the carbon of which the filaments are composed, diamond dust, or a species of carbon closely resembling the diamond, and manufactured by the following process: In a cylindrical steel vessel lined with a suitable refractory material and closed at each end by a screw plug bearing a carbon-pencil in a water-jacketed holder, there is placed carbonic acid in a liquid or solid (snow) form, together with carbon, or a hydrocarbon, such as gasolene. On heating the mixture by means of the voltaic arc, the CO_2 and the hydrocarbon are decomposed, CO being formed and a great pressure thereby generated in the vessel. By the continuance of such high pressure and temperature a very hard and crystalline form of carbon is produced, which after its removal from the vessel can be crushed into extremely fine powder. This powder is mixed with suitable vehicles, such as tar, pitch, or sugar, and then moulded with filaments which are "retorted" and "flashed" in the usual manner. C. K. F.

1253. *The Track Circuit for Railroad Signalling.* **C. C. Anthony.** (Elect. World and Elect. Engin. N.Y. 33. pp. 540–542, 1899.)—The track circuit, which is much in use in America for the automatic control of signals by trains, consists of the two lines of rails of a portion of the track separated from the adjoining rails by insulating rail joints, with the poles of a battery connected to the opposite rails at one end, and the coils of an electro-magnet at the other. The line resistance is very low; the insultation resistance is also very low and variable, and the current in the magnet coils is cut off by shunting, when the rails are connected by the wheels and axles of a train, and not by opening the circuit. With low insulation and shunt resistances it is impracticable to use a high potential or large current. It follows that the track circuit must control electric signal appliances through a comparatively delicate relay.

The relay should be sensitive and efficient. When such a relay has been designed, the relay or battery resistance should be as high as it can be made, with due regard to the necessary provision for the closing of the relay under the most unfavourable conditions expected. Any possible small economy of current that might be secured by a particular arrangement is quite subordinate to the effectiveness of the shunt. So, too, a maximum of energy at the relay from a given battery is not an essential requirement; if the required amount of energy is available under the most unfavourable conditions nothing more is necessary. On the other hand, waste of current on the shunted circuit must be kept within reasonable limits; but the considerable battery resistance required for this purpose is equally useful in making the shunt effective. W. G. R.

1254. *Interior Wiring Systems.* **L. B. Chubbuck.** (Canad. Elect. News. 9. pp. 43–46, 1899. Read before the Engineering Society of the School of Practical Science, Toronto.)—A review of the chief systems used in America. Most work is done with concealed insulated wires run on porcelain knobs under floors or between walls, and in porcelain tubes embedded in the plaster. The modern fireproof construction, however, leaves no space for such work: hence the evolution of conduit systems. Two kinds of iron armoured conduit are used, one lined with treated paper and the other coated with enamel inside and out. The smooth surface of the latter facilitates drawing-in; the former prevents "sweating." To ensure good workmanship no draw-in cords should be put in during erection; after completion a $\frac{3}{16}$-inch steel tape should be pushed through. An 80-foot run with four bends is not an excessive length to thread.

E. H. C.-H.

1255. *Paper Telephone Cables.* (Elect. Rev. 44. pp. 535–537, 1899.)—The specific inductive capacity of gutta-percha is 2·46, of rubber 2·34, of paper nearly unity. The average capacity of a telephone cable should be 0·080. The capacity of an india-rubber cable (presumably similar and of No. 20 S.W.G.) is 0·290 Preference is given to a twisted strip method of covering. The jointing of multiple wire cables, drawing into terminal boxes, drying by the air-pump at a pressure of 15 lb., and localising faults by the issuing air are described. M. O'G.

1256. *Izambard Process of Printing by X-Rays.* (Elect. Engin. N.Y. 27. p. 61, 1899.)—In this process a number of sheets of sensitised paper are piled one on the top of the other, and between the pile and the source of X-rays is the copy, which is printed or written in ink made in part of finely divided metallic or calcareous powder; bronze, copper, white lead, or white zinc may be used; as a writing ink, white lead in a solution of gum; as a type-writing ink, metallic powder mixed with boiled linseed oil. The limit of thickness of the pile that can be printed at one exposure is reached when the rays are distributed so as to distort the image; this limit is about two inches. C. K. F.

1257. *Printing by Means of X-Rays.* **F. S. Kolle.** (Elect. Engin. N.Y. 27. pp. 77–79, 1899.)—The process here described is an improvement on the Izambard process. A number of inks are described suitable for writing, printing, type-writing, &c. A feature of the improved process consists in making the paper in a continuous strip, and sensitising it in page-sections alternately on opposite sides in such a way that, when folded to the proper size, each section will still retain the features of a

single sheet. For printing on both sides of the paper, the page-sections are sensitised in strips with intermediate spaces as in the Izambard process, the spaces on one side of the paper registering with the sensitised strips on the other side. Information is also given as to printing frames, developing apparatus, and other details. C. K. F.

1258. *Power from Blast Furnaces.* **A. Witz.** (Écl. Électr. 18. pp. 401–407, 1899.)—Recent improvements in blast furnaces have resulted in a great increase in the production of pig-iron and a diminution of the fuel used. In America there are furnaces giving a daily output of 700 tons for an expenditure of three-quarters of a ton of fuel per ton of pig-iron. Of the heat developed by the combustion of the fuel only about 29 per cent. is utilised in effecting the necessary chemical changes, and many attempts have been made to utilise the waste heat. In evaporating water in a steam boiler about 22 cubic metres of blast furnace gas are required per H.P. hour. The author has found that the calorific value of blast-furnace gas is on the average 1,000 calories per cubic metre, so the above consumption represents a thermodynamic efficiency of about 3 per cent. In other words, utilising the waste heat to generate power by steam engines and boilers, the best one may hope to obtain is about 450 I.H.P. for a 100-ton furnace.

Gas engines work with an expenditure of two to three cubic metres of poor gas, and in 1894 Thwaite first made the attempt to utilise blast-furnace gas in a gas engine. His first experiment at Wishaw, Scotland, was very satisfactory. The author traces briefly the history of the utilisation of the gas in this manner, gas engines up to 600 H.P. being used; while at Seraing there will soon be in operation a two-cylinder engine of 1,000 H.P. The author is of opinion that a combustion motor would be better than an explosion motor for the utilisation of blast-furnace gases, but this is a type of engine that has yet to be created, and at present the only engines employed have been of the well-known explosion type. The power thus available is more than sufficient for all the operations required at an ironworks, and when the geographical conditions are favourable the excess may be conveniently transmitted and distributed. (See also 1898, Abstracts Nos. 991, 992, and 993.) A. S.

1259. *Elevators for Central London Railway.* (Engineering, 67. pp. 273–276 and 306–307, 1899.)—The lifts selected for the stations of the Central London Railway are made and designed by the Sprague Electric Company, New York. One of the conditions to be complied with was that with an average total of 20,000 single trips per day of 67 feet mean rise, and with current at 1d. per Board of Trade unit the elevators must be worked for three years at a cost not exceeding £1 per 1,000 trips. The diameters of the shafts in which the elevators work vary from 18 feet to 30 feet,

three cars being placed in the larger shaft. Details of the construction and specification of the cars are given. The hoisting machinery is extremely simple and completely self-contained. Side frames mounted on a heavy cast-iron bedplate carry bearings for the drum and idler shafts, and form oil tanks in which the worm-gear is enclosed. Directly coupled to the worm-shafts are the four-pole shunt-wound iron-clad motors, which at 470 revolutions per minute give a lift speed of 200 feet per minute. Each motor drives a shaft on which are fixed right-handed and left-handed worms gearing with two worm-wheels, lateral thrust on the drum-bearings being thus done away with, and the thrust of one worm being balanced by that of the other. As a safety device the usual Sprague jaw clamps are used, specially modified for the conditions. Each safety catch is calculated on the basis of a loaded car weighing 40,000 lb., having to be supported by friction only between the clamps and the guide rails, the assumed frictional coefficient being 15 per cent. As an additional safeguard oil buffers are placed on all cars and counter-weights. These are large dashpots, with plungers, having tapering grooves on their external surfaces, which allow the cars to settle rapidly when the buffer first comes into operation, the settlement becoming slower as the grooves narrow.

The experimental lift erected at Notting Hill Gate under the conditions of the contract has been subjected to rigorous tests with most satisfactory results. A. S.

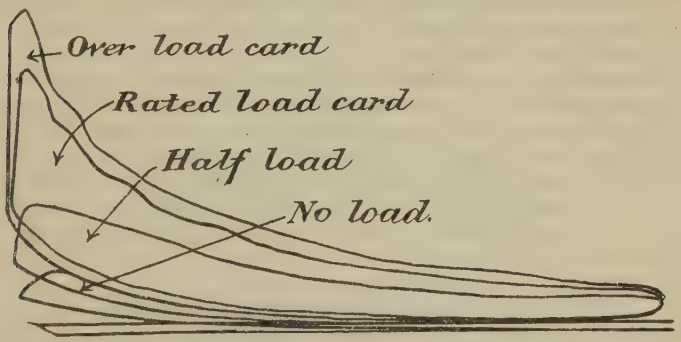
1260. *Recent Developments in Gas Engines.* **E. Ruud.** (Elect. Engin. N.Y. 27. pp. 255–257, 1899.)—Large gas engines work on the "Otto" or "Beau de Rochas" cycle, and fall into two classes, depending on the mode of regulating the speed:—

1. In the "hit and miss" governing type, chiefly in use, one or more charges of gas are cut out altogether. Where uniform speed is required, as in electric lighting, the "hit and miss" gas engine must have heavy fly-wheels, and a heavy balance wheel is usually mounted on the jack shaft. The variation in voltage on a 100-volt circuit is generally from $3\frac{1}{2}$ to 4 volts during the cycle. When the engine takes in a few charges successively the voltage is steady and rising, but when the engine omits one or more charges a momentary variation in speed is the result, and fluctuation is apparent in the lights. The loss of power by the two belts is about 7 per cent., and by the jack shaft 3 per cent., making a total of 10 per cent. taken by the extra machinery. One advantageous feature of this type of gas engine is that the charge is always ignited under the same pressure, and hence the actual work done by the exploding gases in a cycle is practically the same for full load as for no load.

2. In another type of gas engine, adapted for electric lighting, the speed regulation is said to be as good as that of a first-class steam engine. The armature is on the crank-shaft direct-coupled

or directly belted. The mode of governing is similar to that of the steam engine. All charges are proportioned to the load. If the entire load is suddenly thrown off at once, which seldom occurs, there is one heavy charge already in the engine, although the governor acts instantly, and there may be another under way partially reduced by the action of the governor. This tends to speed up the engine slightly above the normal, but it is reduced by the fly-wheels. The indicator diagrams give an idea of the governing action of a Westinghouse gas engine of this type.

The *gas consumption* in all engines varies with the kind of gas used, and also with the size of engine up to certain limits. The average in the Westinghouse gas engine, from 20 H.P. upwards at everyday work, is 10·5 to 12 cubic feet of Pittsburg natural gas per B.H.P. hour. The heating value of natural gas, found by the Junker calorimeter, is about 1,000 B.Th.U. per cubic foot. That is, the engine requires 10,500 to 12,000 B.Th.U. for each B.H.P. hour, giving a thermal efficiency at the shaft of 25·4 and 21·3 per cent. A special engine of 125 B.H.P. used



only 9 cubic feet per B.H.P. hour, or had a thermal efficiency of 28·7 per cent.

The *consumption of water* flowing through the cylinder jackets is about 30 lb., and in summer 38 to 40 lb. per B.H.P. hour. Where water is expensive it may be used over and over again in cooling tanks or by pumping the water to a cooling-tower, and the loss of water need only be a few gallons per week. In some tests it was found that 5,121 thermal units went out in the cooling water, 2,922 thermal units were converted into work, so that 2,957 thermal units must be lost by the exhaust and radiation.

In the spring, 1898, an engine of 650 B.H.P. was completed in the works of the Westinghouse Machine Company. This engine has three vertical cylinders, and speed of 150 revolutions per minute. Another three-cylinder gas engine is in hand, designed to give 1,500 B.H.P. at 100 revolutions per minute on 8½ cubic feet of natural gas per B.H.P. hour, or 8,500 B.Th.U. per B.H.P. hour, that is, a thermal efficiency of 30 per cent. at the shaft.

Such an engine will run every day on less than 1 lb. of coal burned in a producer gas plant per B.H.P. hour, including banking of fires and similar losses. W. R.

1261. *150-ton Electric Jib Crane.* **W. A. Post.** (Elect. Engin. N.Y. 27. pp. 134–137, 1899. Abstract of paper read before the Society of Naval Architects and Marine Engineers.)—Early in 1896 the Newport News Shipbuilding and Dry Dock Company resolved to provide a crane capable of lifting the heaviest single weight likely to be met with in the probable development of modern ships. Careful consideration of all the requirements led to the adoption of a 150-ton revolving crane electrically operated, mounted on a steel tower on pile foundations. The jib is capable of having its outer end raised or lowered, so that the derrick may operate on weights lying within two concentric circles of 207 feet and 88 feet diameters respectively. The feature of varying the radius at which the hoisting may be performed constitutes a most important difference between this crane and the 130-ton steam crane erected in 1893 at Finneston Quay, Glasgow.

The foundations consist of 150 piles in four concentric rows. The steel tower is, in general form, a cylinder 36 feet diameter, and is comprised of sixteen columns braced and anchored to the pile foundations below. A description of the revolving structure is given. The derrick is revolved by duplicate sets of machinery, each motor being of 20 H.P., and working through a double-threaded worm and wheel, which drives a pinion engaging on a circular rack on the outside of the tower. The racking movement of the jib is effected by two $1\frac{1}{4}$-inch steel wire ropes, each rope being wound on alternate sheaves 5-feet pitch diameter on 10-inch steel pins at the upper and inner apex of the jib and at the upper apex of the housing. Each rope is strong enough to sustain the jib when under maximum load. There are two main hoists, each of 75 tons capacity, and one of 20 tons capacity for lighter loads. The drums are $8\frac{1}{2}$ feet diameter, and are driven through a train of gearing by a 100 H.P. electric motor, series wound. These hoists may be coupled together and operated as one hoist of 150 tons capacity. The brakes are powerful, certain, and automatic in action. The brake band is wound $4\frac{1}{2}$ times round a brake cylinder on the pinion shaft, and is of wrought-iron 1 inch thick, 5 inches wide at one end, and tapering to $1\frac{1}{4}$ inches at the other. The broad end is firmly anchored, the narrow one secured to a lever carrying a weight of 200 lb. When lowering, the rotation of the brake cylinders is towards the small end of the band, so that the friction produced by the weight causes the band to wind tight on the cylinder and stop rotation. To release the brake it is only necessary to lift the weight, which is done by means of a wire connected to a lever in the operating-house. In hoisting, the brake releases itself. A. S.

GENERATORS, MOTORS, AND TRANSFORMERS.

1262. *European and American Dynamo Design.* **B. A. Behrend.** (Elektrotechn. Ztschr. 20. pp. 174–175, 1899.)—The most striking feature pointed out by the author is the small number of poles and large current per armature conductor used by the Westinghouse Company. He cites the case of a 1,500-kilowatt generator (550 volts, 2,730 amperes) with only 14 field poles and consequently 195 amperes per armature conductor. Sparkless commutation is obtained by strongly saturating the laminated field-poles, so that armature reaction is necessarily small. A. H.

1263. *Subdivision of Dynamo E.M.F. and Excitation at Half P.D.* **A. Sengel.** (Écl. Électr. 18. pp. 188–193, 1899; also Elektrotechn. Ztschr. 19. p. 544, 1898.)—The first part of the paper deals with the various methods of subdividing the E.M.F. of a dynamo so that, *e.g.*, a single machine may be used for supplying a three-wire network. In the methods described, which are illustrated in the accompanying diagrams (Figs. 1–4), one or more

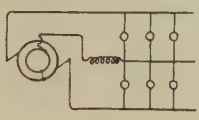


FIG. 1

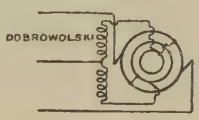


FIG. 2.

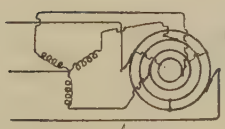


FIG. 3.

FIG. 4.

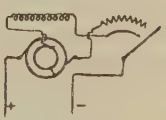


FIG. 5.

points in the armature winding are connected to slip-rings, and by a suitable arrangement of choking coils interposed between the balancing wire and the slip-rings satisfactory working may be secured. Fig. 1 is not to be recommended, as the arrangement is not entirely free from fluctuations in the potential of the balancing wire. Figs. 2 and 3 give satisfactory results. Fig. 4 represents a device due to Ettingshausen; between the slip-ring and two diametrically opposite points in the winding are interposed two auxiliary windings, each covering half the core, and each containing a number of conductors equal to half that in the corresponding main winding.

The second part of the paper is concerned with the methods of shunt-excitation at half the terminal P.D. The arrangement proposed by the author for a short-wound motor is sketched in

Fig. 5. The advantage of such a device lies in the fact that a wire of double the sectional area may be used for winding the shunt, so that the cost of the field winding is considerably reduced.

A. H.

1264. *Armature Design.* **C. Westphal.** (Elektrotechn. Ztschr. 20. p. 118, 1899.)—The author deduces the two following formulæ for the interconnection of the armature conductors in multipolar dynamos :—

$$y=\frac{1}{p}\left(\frac{s}{c}\cdot b\pm a\right) \qquad (1)$$

$$y_1+y_2=\frac{1}{p}\left(\frac{s}{c}\cdot b\pm 2a\right) \qquad (2)$$

where $2p$ = the number of poles ; s = the number of inducing bars or conductors around the armature ; c = the number of these bars in each section ; b = a whole number ; $2a$ = the number of circuits in parallel with each other. In formula (1), which relates to the case where the beginning and end of each element lie on one and the same end face of the armature, y = the "pitch," or number of bars which lie between the commencements of two successive elements in the winding. In formula (2), which relates to the case where the beginning and end of an element lie on different ends of the armature, y_1+y_2 = the double pitch. Reference is made to the work of E. Arnold on *Ankerwickelungen.* C. K. F.

1265. *Sayers' Third-Brush Method of Dynamo Regulation.* **C. P. Feldmann.** (Elektrotechn. Ztschr. 20. pp. 232–235, 1899. See The Electrician, 41. p. 358, 1898.)—Some interesting curves are given, showing the behaviour of a machine under this mode of excitation. No difficulty appears to arise in over-compounding a machine, and there is no sparking trouble due to the unsymmetrical distribution of the armature current through the windings. Objections might possibly be raised from a purely mechanical point of view if the third brush should get damaged, or drop out, or if the commutator were thrown out of truth, the machine might lose its field.

A. H.

1266. *Contact-Resistance of Brushes and Temperature of a Commutator.* **E. Arnold.** (Elektrotechn. Ztschr. 20. pp. 5–7, 1899.)—In this paper curves are given showing (1) the variation of contact-resistance with current density at different angular velocities ; (2) the variation of contact-resistance with angular velocity at different current-densities (these curves present the peculiarity that, as the angular velocity increases, the contact

resistance gradually rises to a maximum and then decreases); (3) the variation of contact-resistance with pressure at different angular velocities. The losses by sparking, by eddy currents, and by friction are also investigated. Methods of calculating the dimensions of commutators so that a given rise in temperature shall not be exceeded, are also given. Reference is made to some researches of G. Dettmar on contact-resistance, published in the Elektrotechn. Ztschr. Heft. 16. 1898. C. K. F.

1267. *Balancing of Armatures.* **C. W. Hill.** (Elect. Rev. 44. pp. 546–547, 1899.)—The best way of testing the balancing of armatures is to test with that force which it is desired to compensate, that is to say, the centrifugal force itself. To do this the armature should be mounted in bearings which are free to move, then while the armature is running the heavy side can be found with a piece of chalk and counterweights adjusted on the opposite side until the cessation of movement of the bearings shows that the centre of gravity coincides with the axis of the shaft. W. G. R.

1268. *Theoretical Dynamo Without Brushes.* **A. Campbell.** (Elect. Rev. 44. pp. 581–582, 1899.)—Let PMQN in Fig 1 be a Wheatstone's bridge in which B is a battery, and let the four arms be of equal non-inductive resistance, but two of them, PM and MQ, of pure bismuth. Now let a strong magnetic field cut

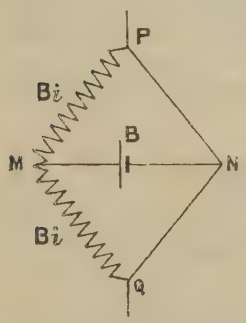


FIG. 1.

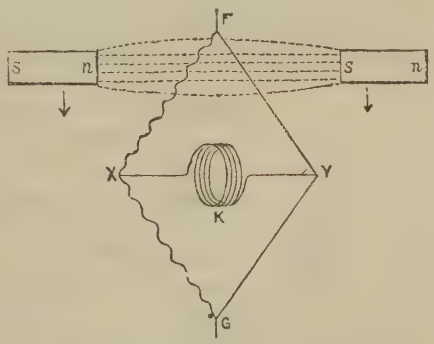


FIG. 2.

alternately the two bismuth arms. This will cause an alternating potential difference between P and Q.

In Fig. 2 the battery is replaced by a coil, K, with its plane perpendicular to the plane of the paper. If the magnetic flux now moves downwards from F to G, and be followed at a distance equal to FG by a series of similar fluxes, an alternating E.M.F. will be set up in the coil K. Owing to the action of the bismuth

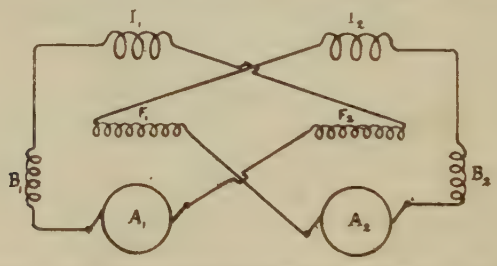
arms, however, a unidirectional potential difference will be produced from F to G, and a rectified current may be taken from these points.

The author extends this principle by making all four arms of bismuth. W. G. R.

1269. *Rotary Balancers.* **C. B. Davey.** (West. Electn. 24. pp. 154–155, 1899.)—The best arrangement for a balancer is that of a single machine having two windings on its armature and two commutators. This gives the best results with a minimum of trouble, the losses also being the lowest possible. W. G. R.

1270. *Dynamo-Electric Machinery.* **C. F. Guilbert.** (Écl. Électr. 18. pp. 298–304, 1899.)—This is an article on the various attempts to reduce magnetic leakage in dynamos. W. G. R.

1271. *Induction Generators.* **M. Leblanc.** (Écl. Électr. 18. pp. 161–167 and 376–379, 1899.)—The author describes and works out the theory of a special form of single-phase induction machine in which the six-pole inducing winding is carried by the rotor, while the induced two-phase winding is embedded in the stator. As is well known, such a machine when started will go on running as a motor at a speed a little below that of synchronism. If run up to a speed above synchronism it acts as a generator. Such induction generators may be coupled in parallel and made to supply a distributing network, developing the whole of the



load current; but they are incapable of developing the idle component of the current, so that this latter must be supplied by an alternator of the usual type. Induction generators may also be coupled in series, and are in that case capable of developing the whole of the E.M.F. component which is in phase with the current: but the component in quadrature with the current must be supplied by a special source. Whether coupled in parallel or in series, induction generators need not run synchronously: in this respect they resemble continuous-current machines, those

which run faster taking a larger share of the load. These theoretical deductions have been fully verified experimentally on a large scale.

In order that an induction generator may be capable of developing currents in quadrature with the E.M.F., it is necessary to fulfil the condition $\lambda L < M^2$, where λ is the inductance of the induced or short-circuited winding, L the inductance of the inducing winding, and M the mutual inductance of the two windings. Normally, of course, λL is always greater than M^2. The author considers two methods of artificially decreasing λ so as to make $\lambda L < M^2$, and thus enable the induction machine to develop idle as well as load currents. The first method consists in using a capacity to balance the inductance λ; ordinary condensers are not suitable for this purpose, as the frequency of the currents is extremely low. Electrolytic condensers, on the other hand, may be used with advantage; they may be considered as ordinary condensers of enormous capacity, which break down as soon as the terminal P.D. exceeds 1·4 volts; they will keep cool so long as the current density does not exceed the limits used in charging accumulators. The second method consists in using a special form of exciter, the arrangement of connections for a two-phase generator being shown in the accompanying figure. The exciter consists of two small continuous-current dynamos, whose armatures, A_1 and A_2, are mechanically coupled. The fields are laminated, and are provided with two windings: F_1 and F_2 are the ordinary field windings, while B_1 and B_2 are balancing windings which counteract armature reaction. I_1 and I_2 are the induced windings of the two-phase induction machine. On account of the very low frequency of the currents circulating in I_1 and I_2 there should be no difficulty as regards sparking. By arranging the connections as shown in the figure it becomes possible to make each armature develop an E.M.F. which is in quadrature with the current in the corresponding circuit.

A. H.

1272. *Parallel Running of Alternators.* **M. Leblanc.** (Écl. Électr. 18. pp. 123–128, 1899.)—The oscillating movement, which is frequently superposed on the motion of rotation of an alternator running in parallel with others, is very effectively damped by the action of a squirrel-cage of copper embedded in the pole-pieces. A large fly-wheel alternator constructed on this principle is illustrated and described. (A full description will be found in The Electrician, 38. p. 210, 1896; or El. Eng. 20. p. 598.)

A. H.

1273. *Parallel Running of Alternators.* (Elect. Engin. 23. pp. 404–405, 1899; also Elekt. Runds.)—The speed of an engine when loaded is more uniform than when running light. Hence

if an incoming alternator, which is properly synchronised but is running light, is connected across the 'bus bars, it will draw a heavy current on account of the much greater momentary variations of its speed than those of the loaded machines. In order to prevent this, artificial loads consisting of resistance wires have in some cases been used; these, however, are generally somewhat expensive. The method recently patented by G. Dettmar consists in using a magnetic brake, which acts upon the fly-wheel of the driving engine: by loading the engine the required degree of uniformity in speed may be reached, and the incoming machine thrown into parallel with the others without any trouble. A. H.

1274. *Relative Dynamo and Motor Capacities.* **A. D. Adams.** (West. Electn. 24. p. 243, 1899.)—With motor and dynamo ratings, each based on the same winding losses, and, consequently very nearly the same temperature rise, the motor capacity of any machine may be found from its dynamo rating by adding to this rating twice the watts in the shunt-winding and then multiplying this sum by the efficiency of the dynamo, provided the motor and dynamo ratings are based on the same voltage at the brushes. If, as is frequently the case, the volts at the motor are less than the volts on which the dynamo rating is based, then the motor capacity as found above should be reduced in the proportion of the volts at the motor to those at the dynamo brushes. Were the above relation between dynamo and motor ratings generally followed, a variation in the ratio between machines would indicate at once a variation in magnet-coil loss, or efficiency, or both. W. G. R.

1275. *Induction Motors.* **E. Wilson.** (Instit. Elect. Engin. Journ. 28. pp. 321–355. Discussion, pp. 356–363, 1899.)—This is an account of some experiments on a 15 H.P. induction motor. The object of the experiments is to investigate the armature reaction and starting torque, as the external resistances placed in the rotor circuits are varied. The motor has a three-phase winding. The results obtained show that as the rotor resistances are increased the phase differences of the induced electromotive forces and currents increase up to the point of maximum torque; after this the effect at 52 periods per second is to slightly increase the phase difference, but at 95 periods per second the phase difference is decreased. An examination of the tables given shows that the armature reactions are very violent when the rotor is short-circuited at start. The torque fluctuates between positive and negative values; the effect is a differential one: on the whole there is a small positive torque. When the rotor resistance is very large the induced electromotive forces and currents are practically in phase, and the torque is small

because the currents are small. As the rotor resistance is diminished, a lag of current behind electromotive force ensues, but the current increases as also the torque. This goes on till the torque reaches a maximum value. On still further diminishing the rotor resistances the torque decreases.

The paper includes eighteen tables of experimental data.

In the discussion, **W. M. Mordey** inquired how it is that waste field involves dissipation of energy, which the author answered by defining the waste field to be that which did not interlink both circuits.

Field pointed out that the air-gap in the motor was unnecessarily large. W. G. R.

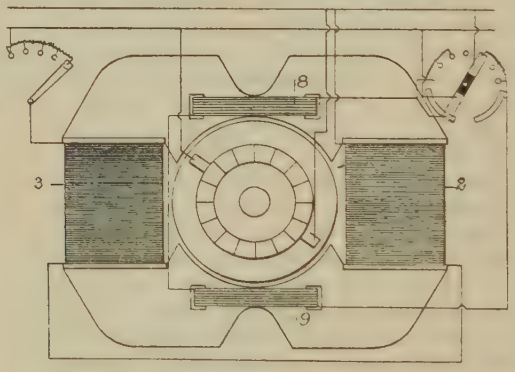
1276. *Induction Motors with Large Starting Torque and Overload Limit.* **T. Marcher.** (Elektrotechn. Ztschr. 20. pp. 235–238, 1899.)—The first step in the design of an induction motor is the determination of its dimensions, which may be obtained by using the formula given by Kapp, viz., H.P. = K . d^2ln, in which d stands for the diameter, l for the length (in cms.), and n for the revolutions per minute; K being a constant which depends on the frequency, and which for a frequency of 50 ∿ varies from $0{\cdot}5 \times 10^{-6}$ to $0{\cdot}7 \times 10^{-6}$. If next, a certain value of B is assumed, the number of turns per phase on the stator coils may be calculated. But the behaviour of a motor designed after this fashion may not be satisfactory, as the relation between load, power-factor, and efficiency may be far from what is desired. The author describes some experiments on two 15 H.P. two-phase motors, identical in every respect, except as regards the stator windings, the number of turns in one of the motors being 1·34 times that in the other. Tests of these motors showed that they possessed totally different characteristics. The motor with the larger number of turns on the stator reached maximum efficiency and maximum power-factor at about normal load, was capable of standing an overload of about 50 per cent., and had a small starting torque; the other motor reached maximum efficiency at double its normal load, could stand an overload of over 300 per cent., and had a large torque at starting. The author next considers the best plan of setting about the design of motors which are required to furnish a large starting torque and be capable of standing a heavy overload (conditions which must be fulfilled by traction motors). To secure these results, the effective impedance of the motor must be kept low. He recommends the manufacturer to carefully measure the effective resistance [watts ÷ (current)^2] and effective impedance (P.D./current) at various loads for several sizes of motors which have been found to fulfil the required condition. By plotting the values of the effective inductance, when the motor is running light, the inductance L of any intermediate size of a similar type of motor may be found. The number of

turns S in the stator windings is then found by using the formula $L=4\pi\left(\frac{S}{2}\right)^2/(10^9R)$, where R stands for the reluctance of the magnetic circuit; R is determined from the known dimensions of the motor (K being known). In order to maintain the resistance of the rotor at a low value, the author recommends the use of rotors provided with a three-phase winding in connection with two-phase stators, since in that case a greater number of conductors is active at any instant than with a two-phase rotor.

A. H.

1277. *Induction Motor Diagrams.* **C. C. Hawkins.** (Electrician, 42. pp. 866–869, 1899.)—This concludes a series of articles on the graphical study of induction motors. (See 1899, Abstract No. 915.) W. G. R.

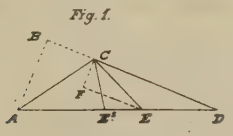
1278. *Controlling Motor Speed.* **F. A. Johnson.** (Elect. World and Elect. Engin. N.Y. 33. pp. 556–557, 1899.)—The author describes a method, due to himself, of controlling the speed of motors, which consists in maintaining a strong and practically constant magnetic field at the pole-tips, where such is needed for sparkless commutation, while the magnetism of the remainder of the pole-face is varied to control the speed of the

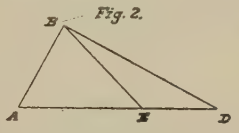


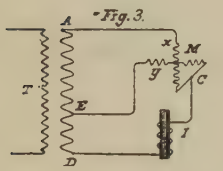
motor. One way of accomplishing this is illustrated in the accompanying figure. The coils, 8, 9, are so placed as to send lines of force through the centres of the pole-pieces, and their effect on the pole-tips is slight. Now, if a current, variable at will in direction and intensity, be passed through these coils, a wide range of speed may be obtained without sparking at the brushes. For, while the total flux will be greatly varied, the field in which the armature coils undergo commutation will remain practically constant. W. G. R.

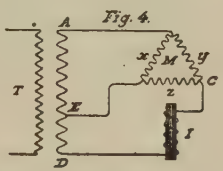
1279. *Transforming Single-Phase to Polyphase Currents.*—(Elect. Engin. N.Y. 27. p. 133, 1899.)—A method of deriving two or more alternating currents differing from one another in phase from a source supplying single-phase currents has been devised by H. A. Wagner, of St. Louis. The accompanying figures show how this is accomplished.

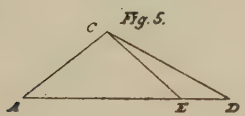
In Fig. 1 AD represents in magnitude and direction the











electromotive force of a source, such as the secondary of a transformer, CD the electromotive force across the terminals of an inductance coil, forming a derived circuit differing in phase from the electromotive force AD by the angle ADC, and AC the resultant electromotive force across the terminals of a working circuit derived from the source AD and made to differ from it by the angle CAD through the effect of the inductance CD.

If another circuit is connected from the point C to some point E on AD, an angle ACE is formed with the circuit AC. This angle represents the difference of phase between the derived circuits AC and CE. The point E may be moved in either direction along AD to any other position as E^1, and the phase relation of CE, as well as its relative electromotive be altered as desired. If there is no self-induction in the circuit AC, it will assume the position AB at right angles to BD, and the relative phase angles and magnitudes then acquired by the different circuits are shown in Fig. 2. The flow of a comparatively large amount of current in a derived circuit such as CE will cause a slight decrease in the angle CAD by the nearer approach of C to D. This can be corrected by increasing the inductance CD, or the phase relations between AC and CE can be retained by moving the point of connection E.

Fig. 3 shows the application of the principle to the operation of a two-phase motor. T is a transformer with secondary coil AD. M is a motor with its two sets of coils, x and y, joined at C and with their other terminals connected, one to A and the other to E, and I an inductance connected between C and D.

Fig. 4 represents a three-phase motor M with sets of coils, x, y, and z.

Fig. 5 shows graphically the phase angles obtained in the arrangement given by Fig. 4. W. G. R.

1280. *Rotary Converters.* **Aliamet.** (Electricien, 17. pp. 114–118, 1899.)—The paper is concerned with general considerations regarding the action of converters, and with the principles underlying their design. If the alternating E.M.F. be supposed to be a sine function of the time, then the relation between E_a, the R.M.S. value of this E.M.F., and E_c, the continuous E.M.F., is given by the formula $E_a = \frac{E_c}{\sqrt{2}} \cdot \sin \frac{\pi}{n}$, where n is the number of phases. In general, however, the sine law is not fulfilled. Further, if the converter be used for transforming alternating into continuous currents, the form of the P.D. wave will depend on the nature and amount of the load fed by the network, so that the ratio of alternating to continuous voltage will not remain constant. If the alternating P.D. is kept approximately constant for all loads, the continuous P.D. may undergo considerable fluctuations. A good deal of trouble may arise on account of sparking at the commutator if the converter is a continuous-to-alternating one, and is working on an inductive load; this sparking is due to the lag between P.D. and current. If the load changes from a non-inductive to an inductive one, violent sparking may take place without any apparent reason. All these difficulties have been largely overcome in the most modern types of converters; the main improvements consisting in largely reducing the amount of copper on the armature, in increasing the number of commutator segments, and in using large air-gaps and working at a high gap induction. These changes are, of course, accompanied by a corresponding increase in the cost and size of the machine, so that a modern rotary converter, if used simply as a continuous-current generator, would give a very low output in comparison with dynamos of usua construction. If the output of a converter as a continuous-current dynamo be denoted by unity, then on the basis of the same rise of temperature its outputs as a converter would be: Single-phase, 0·85; three-phase, 1·34; quarter-phase, 1·64; six-phase, 1·96. A. H.

POWER DISTRIBUTION, TRACTION, AND LIGHTING.

1281. *Electric Power in Workshops.* **C. M. Barber.** (Mech. Eng. 3. pp. 159–160, 1899.)—In this paper the author briefly deals with the chief considerations bearing on the use of electromotors in place of long countershafts and belting. Overhead shafts and belts interfere with travelling cranes, and require heavy roof columns. With motor driving, each machine is self-contained, and can be put down in any desired position. The first cost of motors is greater, but the maintenance less, than with shafting. Numerous tests show that the loss in mechanical transmission varies between 10 and 80 per cent. of the power applied, the average being about 30 per cent.; the electrical loss is about 22 per cent. Smaller driving plant is needed with motors; *e.g.*, in a lithographic works the rated output of the generators was 50 per cent. of that of the motors, the maximum load 32·7 per cent., and the average load 17·6 per cent. The speed of motors is easily and economically varied between wide limits, and low-speed motors are now obtainable of all sizes; the works should, however, be designed to use high speeds wherever possible.

In the discussion, **C. H. Benjamin** stated that he found the average mechanical loss in a number of works to be about 55 per cent. **J. H. Sherwood** gave details of tests made on very heavy shafting and belting, where the loss was only 10 per cent.; in this case the bearings were carefully lined up every month.

A. H. A.

1282. *Electric Power in Workshops.* **H. A. Mavor.** (Mech. Eng. 3. pp. 234–236, and 270–271, 1899.)—The author is of opinion that electric power will never be less costly than power obtained from gas engines, though other considerations are likely to result in electricity being preferred. The rapid spread of electric traction will most probably lead to a reduction in the cost of dynamos and motors. The author classes factories into two groups, viz., those which cover a small area, and those which require power at widely scattered points. A diagram is given showing the various losses incidental to the use of shafting, as compared with electricity. In the case of the first group, the total loss between I.H.P. and useful H.P. at the machines is about 25 per cent. with either system. A diagram is also given showing, in the case of the second group, the capital and running costs for distribution by shafting, steam, and electricity, with a load factor of about 60 per cent. The initial expense is about the same in each case; the running cost of shafting is slightly less than that of electricity, but both are much less than that of steam. In preparing the diagrams, the steam consumption per I.H.P. hour was assumed to be 30 lb., but in practice the average

of 100 engines in eight factories was found to be 47·7 lb. In a 120 H.P. installation known to the author, the adoption of electricity led to a saving of over 50 per cent. of the fuel previously used, or about £100 per month. The author believes direct current to be decidedly superior to polyphase currents in factories. The necessity for speed-reduction gearing is briefly dealt with. A. H. A.

1283. *New Union Station, Boston, U.S.A.* (Elect. World and Elect. Engin. N.Y. 33. pp. 297–303, 1899.)—An illustrated description of the 1,500 H.P. electrical generating plant, elevators, and signal operating devices. Signals are worked pneumatically, the valves being actuated by electro-magnets and also interlocked electrically. Induced draught is used, and a short steel stack of $\frac{3}{8}$ inch plate and 11 feet diameter. The chief elevators are controlled by push-buttons, operating pilot motors which revolve the controllers. E. H. C.-H.

1284. *Central Power House, Boston Elevated Railway.* **H. W. Weller.** (Railway World, 8. pp. 124–131, 1899.)—This station has been erected to operate the lines of the West End Street Railway Co. The engine-room is 147 feet × 173 feet, and the boiler-room 230 feet × 86 feet. The chimney is 252 feet high by 13 feet 8 inches inside diameter. There are twenty 250 H.P. and eight 500 H.P. Babcock boilers. An electric locomotive dumps coal in front of the furnaces and removes ashes. The main damper is operated automatically. Steam piping, which is in sections and not in duplicate, is extra heavy, with copper bends, flanged joints fitted with copper gaskets, and steel fittings. A 3,000 kw. unit is being erected, and there are already running six 1,600 H.P. and two 2,000 H.P. triple-expansion condensing sets. Some of the steel-plate fly-wheels running at 80 r.p.m. are 24 feet in diameter and weigh 60 tons. Independent steam connections are provided, so that either cylinder may be disconnected, and the other operated alone at high pressure in emergencies. The switchboard is of the usual standard type, the main panel containing a 25,000 ampere Weston ammeter. E. H. C.-H.

1285. *Cleveland Electric Railway Power Station.* (Street Rly. Journ. 15 pp. 199–205, 1899.)—A 2,400 kw. 22-pole generator has recently been added. Its armature is 12 feet in diameter and 2 feet across the face, with bars of such shape that no joint occurs at the fly-wheel end. The generator weighs 180,000 lb., and has a shaft 20 inches in diameter. Its width is 270 inches, and its length along the shaft 61 inches. It is direct-coupled to a vertical cross-compound non-condensing engine running at 75 r.p.m. with

160 lb. pressure. The fly-wheel is 25 feet in diameter, and weighs 160,000 lb. The shaft is 25 feet long, with spherical bearings 4 feet long. Ten 264 H.P. B. and W. boilers are connected by 8-inch pipes to a 20-inch steam header. The coal-handling equipment is very complete, including storage capacity for 900 tons of coal. The smoke-stack is of steel lined with brick, self-supporting, and 225 feet high, with a flue 10 feet 6 inches inside diameter, while the bell-shaped base is 25 feet in diameter and anchored to the foundations. The engines are run non-condensing, because the exhaust steam is supplied to the evaporating appliances in a neighbouring salt mine. The switchboard contains an automatic circuit-breaker of 6,000 amperes capacity.

All short cars are being replaced by long bogie cars. In the motor repair shop, a dismantling appliance is used, consisting of a timber truss of the same length as the car on each side of the pits. These trusses are elevated by screws connected together with bevelled and worm gear driven by a motor, both trusses being elevated simultaneously. By placing timbers from one truss to the other under the car body, the car is elevated and held firmly in position, so that the axles and motors can rapidly be run out. A portable hydraulic device for removing armatures is also provided. The shop tools, including a Murphy wheel grinder, are driven by a 75 H.P. electric motor. E. H. C.-H.

1286. *Calculation of Power and Use of Accumulators for Electric Traction.* **L. Schröder.** (Elektrotechn. Ztschr. 20 pp. 111–115, 1899.)—The first part of the paper deals with the methods of determining the power required for a given service of cars of known weight and carrying capacity along a line of known gradients. In making this calculation the author assumes a combined efficiency of 70 per cent. for the motors and gearing, and adds 25 per cent. to the pull required to overcome friction in order to allow for starting; in the case of small plants a larger allowance must be made, since most of the cars may happen to be starting at the same time. The second part of the paper is concerned with the advantages of stationary accumulators in power stations. In order that the cells may act as efficient regulators, the generators must be shunt-wound machines with a considerable droop in their characteristic. The following rule is recommended by the author with regard to the size of the cells. For plants requiring a current not exceeding 200 amperes, the cells should be capable of standing a *charging* current equal to the normal current of the generator. For plants requiring about 600 amperes, the cells must be capable of standing a *discharge* current of this amount. For intermediate sizes of plant intermediate sizes of cells are used, the ratio of the maximum *charge* to the maximum *discharge* current being generally 3 : 5. The cells should be capable of discharging at their maximum rate for one hour. A. H.

1287. *Working Expenses of Electric and Cable Railways.* (Railway World, 8. pp. 132–133, 1899.)—Details are given of the expenses, receipts, &c., of the only three lines in England the accounts of which are available. The totals for the last half of 1898 were as follows :—

LIVERPOOL OVERHEAD ELECTRIC RAILWAY.

Expenses per train mile.	Receipts per train mile.	% of Expenses to Receipts.	Miles run.	Passengers carried.
14·92	26·12	57·12	373,560	4,894,921

CITY AND SOUTH LONDON ELECTRIC RAILWAY.

15·88	28·28	56·15	234,166	3,462,814

GLASGOW DISTRICT CABLE SUBWAY.

7·13	15·54	45·38	554,770	6,666,082

To facilitate comparison of these results, the following data are given :—

	Liverpool Overhead.	City and South London.	Glasgow Subway.
Number of cars in train	2	3	2
Passenger accommodation (seated)	114	96	66
Weight of train, empty	31 tons	31 tons	13½ tons.
Weight of train, all seats occupied	38 tons	37 tons	18 tons.
Receipts per passenger carried	2d.	1¼d.	1½d.
Length of railway (double track)	6¾ miles	3 miles.	6¾ miles.
Train miles run per double-track mile.....	55,342	78,055	82,151

From the Glasgow statistics, where single gripper cars were used in the early part of the year, and trail cars in the second half-year, it appears that an increase of 50 per cent. in the dead load of cars made no increase in total working expenses, showing the merit of cable haulage for heavy work. E. H. C.-H.

1288. *Bristol Electric Tramways.* (Railway World, 8. pp. 85–96, 1899.)—A *résumé*, brought up to date, of descriptions of the Bristol Tramways system. A return booster circuit has been added, which reduces the drop on the return from 9 volts to 3 volts. E. H. C.-H.

1289. *Rapid Transit in Cities.* J. Lundie. (Street Rly. Journ. 15. pp. 228–230, 1899.)—The variations in speed on any given schedule determine (*a*) the necessary weight on the driving wheels required to give sufficient adhesion for acceleration; (*b*) the power and capacity of the necessary motor equipments; (*c*) the total energy to perform the movement. The two extremes in

performing any given average running speed are, (i.) accelerating up to the point of braking; (ii.) accelerating as rapidly as possible to above average speed, and then coasting or keeping this speed to the point of braking. To make a given distance in a given time with the first extreme requires the least powerful motors, but the maximum amount of energy: with the second extreme, the most powerful motors are required, but the minimum amount of energy is used. E. H. C.-H.

1290. *Tramway Permanent Way.* **W. H. Rosencrans.** (Street Rly. Rev. 9. pp. 181–183, 1899.)—Sections of the road-beds in several American cities are given. With 60-feet rails a $\frac{3}{16}$ inch space should be allowed at 50° F., or $\frac{1}{16}$ inch at 90° F. Where covered to their full depth in paved or gravelled streets, however, 60 feet rails may be laid with closed joints.

E. H. C.-H.

1291. *Tramcar Design.* **H. Mozley.** (Railway World, 8. pp. 145–146, 1899.)—The weight of electric cars makes the adoption of a power brake advisable. If an air brake is used, a sand blast arrangement might be coupled to the sand boxes to secure efficient sanding with a minimum of sand. According to a report to the American Street Railway Association at Boston, Sept. 6, 1898, upon bogey and four-wheel cars, the latter type necessitates too long a wheel base, is subject to vertical oscillations, "pounds" the track, and is insufficient for "rush-hours." The bogie car with motors on all four axles largely obviates these objections, and is operated with greater economy in wages, which is an important item, being 52 per cent. of the gross cost of working. E. H. C.-H.

1292. *Inspection of Street-Car Equipments.* **A. B. Herrick.** (Frank. Instit. Journ. 147. pp. 360–377, 1899.)—The resistance of starting rheostats often increases with age, sometimes quadrupling. The car will not then start on the first notch, but gives the "kangaroo start" on the second notch; the motors then have to carry, and the station has to supply, more current. Faulty rheostats are the real cause of many burnt-out fields which often result in burnt-out armatures and other troubles. Frequent measurements should be made of the resistances of the various circuits, including motor brushes and controller contacts, which should be carrying their normal currents. A modification of Kelvin's method is the only reliable one for these tests.

Coils should not be dried by passing current through them, because electrolysis then forms copper salts with the water or alcohol and destroys the insulation. Baking ovens should be ventilated or they act only as steam boxes. The two motors

should be equal within 8 per cent.; the best test of this is the change in drop of volts across the fields (carrying the same current) on the series and parallel notches. Two-way connectors are responsible for many troubles. E. H. C.-H.

1293. *Trolley Car Mishaps.* **S. Woodfield.** (Lightning, 15. pp. 304–305, 1899.)—A recital of actual accidents to trolley cars and their equipments on the road, with hints as to immediate repairs by the motor-man. E. H. C.-H.

1294. *Accumulators for Motor Cars.* **P. Northey.** (Automotor Journal, 3. pp. 202–204, 1899.)—The Crowdus cell gave the author 10 watt-hours per lb. of complete cell at a four-hour rate, as against the corresponding figure of 7·6 watt-hours for the best of the ordinary makes. The weight of its grid is only one-third of the finished plate. The positive plates are surrounded by a cellulose jacket, which prevents the continued wash of acid against the faces. Perforated hard rubber separates the positive and negative sections. The cell plates are connected both at top and bottom corners under the level of the acid. Comparing the cost of maintenance of a horse-drawn and electrical-driven brougham, holding two persons and driver, and travelling 11,000 miles per annum, the author gives £105 10s. as the annual cost with horses, and £67 10s. with electricity. The items are: Two horses, including fodder, shoeing, and veterinary charges, £83. Depreciation at 12½ per cent. on £180 (the cost of two horses), £22 10s. 3,790 units at 3d. (allowing a 1·4 ton vehicle, to run 30 miles with one charge and an energy efficiency of 77 per cent.), £47 10s. Upkeep at 25 per cent. on the 8,000 watt-hour battery, costing £80, £20. No acid should be used without testing, as different batches from same makers vary greatly. Nitrogen compounds, arsenic, iron, copper, and hydrochloric acid are objectionable. Care must be taken against impurities introduced by corrosion of cell connections.

Discussion (pp. 204–206.)—**Oppermann** had found that cellulose envelopes would not stand sulphuric acid for long. If a battery were made costing £40 and lasting only two years, it would pay to use it on electric vehicles. E. H. C.-H.

1295. *Foel Motor Car.* (Elect. Rev. 44. pp. 543–544, 1899.)—Two comparatively slow speed motors are used, one on each hind wheel. The field magnet is centrally wound on a steel core with twelve radial pole-pieces, outside which the tunnel-wound armature built up on laminated rings, revolves. The two B.H.P. size can be worked up to three B.H.P., runs at 600 revolutions

per minute, weighs 1 cwt. and gives 90 per cent. efficiency at full load. The carriage body is carried on a rectangular underframe of steel tube suspended on springs and connecting the axles together in place of the usual "perch-bar." This frame safeguards the motors from shock. The armatures carry sprockets, driving bicycle chains which drive the carriage wheels by leather-covered pulleys without sprockets. This is found efficient, convenient for turning, and capable of negotiating hills of 1 in 8. The motors are self-adjusting for turning corners. Twenty cells are carried under the driver and twenty under the back seat. The forty cells complete with boxes weigh 8 cwt. Each cell weighs 22 lb. complete, takes a normal charge of 20 amperes, and, at 20 amperes discharge rate, has a capacity of 140 ampere-hours, or 13 watt-hours per lb. of complete cell, and 17 watt-hours per lb. of plate only. At a 40 ampere rate the capacity is 120 ampere-hours. The total weight of the carriage, which carries a driver and three inside passengers, is 1 ton, and it will travel 50 miles with one charge on good ordinary roads. Slight depression of the foot-brake puts resistance in the motor circuit; further depression breaks the circuit. E. H. C.-H.

1296. *Motor Car Design.* **T. H. Parker.** (Elect. Rev. 44. pp. 481–482 and 525–526, 1899.)—Experiments with a horse drawing a brougham through a spring-balance showed that an unloaded electric car for six persons, equipped to run for three hours at 8 m.p.hr. must weigh at least 25 cwt. The author first tried two series motors at 950 revs. per min., which each gave 30 lb. torque at the periphery of the armature carrying 25 amperes. The front and back wheels were made to move simultaneously through the same angle in opposite directions, so that the car turned in its own length and all four wheels could be driven if desired. Owing to difficulties in holding the car on hills, the motors were rewound as shunt machines with surprising results. Instead of the usual rush of current (50 amperes) at starting, the car moved steadily away with less than 10 amperes, and when up to speed only took the same current as with series motors. With the controller on a given notch the speed hardly varied; on the stiffest down grades the speed did not rise 5 per cent., and 20 amperes charging current were sent into the battery. The author states that, without use of brakes or reversing motor, the car was arrested in 3 feet on a 10 per cent. grade at full speed. The motors develop two B.H.P. at 560 r.p.m. and weigh $2\frac{1}{2}$ cwt. each. Special tangent wheels were used having two spokes formed by one wire; the loop formed at the hub-end is fastened by pins through the double flanges of the hubs. No reasonable strain will wrench such spokes from the hub, and the method permits hub and sprocket being cast in one piece. E. H. C.-H.

1297. *Electric Brakes as Recuperating Devices.* **F. B. Booth.** (Elect. World and Elect. Engin. N.Y. 33. pp. 435–436, 1899.)—The objection to combining the functions of electric braking and recuperation of the cells is that all the retarding force of the brake has to be transmitted through gearing which is liable to be stripped. The best form of electric brake is a mechanical shoe applied by an electromagnet energised by the motor running as a dynamo or by current from the battery when the speed decreases. It is impracticable to use the charging combination as an emergency brake; it should only be used on steep hills, and its retarding qualities should be regarded as incidental. Consider a vehicle of 2,000 lb. with pneumatic tyres; this would require 50 lb. draw-bar pull on good level roads at moderate speeds. On descending a 5 per cent. grade, gravity exerts a pull of 100 lb., or 50 lb. in excess of the pull necessary to maintain the assumed speed of 5 m.p.h. downhill. Assuming an overall efficiency of 66·5 per cent., the power returned to the batteries will be only 243 foot lb. per second, whereas to ascend the same grade requires 1,447 foot lb. per second. The energy returned will only propel the vehicle for a level distance equal to half the length of the hill descended. Curves are given showing the maximum percentage of return on different grades, proving that a recuperating device is valueless unless grades of more than 6 per cent. are frequently encountered. E. H. C.-H.

1298. *Moore's Truck.* (Street Rly. Rev. 9. pp. 178–179, 1899.)—This novel truck has been developed in Chicago City Railway Shops. It has longitudinal pine sills, $3\frac{1}{2} \times 4\frac{1}{2}$ inches, strengthened by $\frac{5}{8}$-inch steel plates on the outside. The cross-ties and motor supports are of oak. The pedestals are so arranged that the wheels can be taken out without interference with the car body. The oil boxes allow $1\frac{1}{4}$ inches play laterally in each direction. The brake-shoe hanger has a ball-and-socket attachment, to secure uniform wear of wheels. The car body rests on 16 cup-shaped rubber insulators and the absence of metallic contact between track and car body secures easy, noiseless riding. Practically no forgings are used on the truck, but only malleable iron castings. E. H. C.-H.

1299. *Breakage of Car Axles.* **J. F. Thompson.** (Street Rly. Journ. 15. pp. 211–213, 1899.)—This paper contains a number of photographic reproductions of fractures of steel axles, some of the fractures having taken place during ordinary working, and others having been made on new axles. The weakest point, where the fracture takes place, is sometimes on the outside of the wheel next to the journal, and sometimes on the inside, according to the type of motor used. Shoulders and sharp corners in

steel axles should be avoided as far as possible. Iron castings stand a better physical test when they are a year or two old than immediately after casting. Observations show that where chilled cast-iron car wheels break in service, it is quite early in the life of the wheel; which seems to prove that there is no tendency to crystallise, but rather that the effect of age is to increase the strength of the iron. If this is correct as regards cast iron it would also seem reasonable with regard to hammered iron or steel. A. S.

1300. *Use of Magnets instead of Springs in Trolley Bases.* **A. Hecker.** (Zeitschr. Elektrotechn. 5. pp. 38–40, 1899.)—The trolley pole must be allowed considerable up-and-down play in cases where the height of the overhead conductor above the rails is very variable. It then not unfrequently happens that on the trolley leaving the conductor the pole strikes and breaks a number of span-wires before the car comes to rest. In order to avoid this risk, the author proposes to dispense entirely with springs in the trolley base, and to substitute for them a coil-and-plunger mechanism traversed by the main current. If the trolley should be thrown off the conductor, the excitation of the magnet ceases, and the trolley pole falls down by gravity out of harm's way. Illustrations are given showing details of the proposed arrangement. A. H.

1301. *Controlling Stray Currents on Electric Railroads.* **M. Kallmann.** (Elektrotechn. Ztschr. 20. pp. 163–171, 1899.)—In this paper there are described methods for determining the resistance of rails used as return conductors, firstly, when the sections of the line to be tested are isolated, and secondly, during working; methods for controlling the differences of pressure at the various feeding-points of the rail during working, and the differences of potential occurring between the rails and other metallic conductors in the roadway; and also methods for determining the earth currents escaping from the rails. The methods given are very fully discussed by the aid of diagrams. Reference is also made to earlier work on this subject.

C. K. F.

1302. *Rail Bonding.* (Zeitschr. Elektrotechn. 4. pp. 32–33, 1899.)—The method consists in using a supplementary copper conductor which follows the line of the track and is bonded to each length of rail. The bond itself consists of a thimble and short, flat pin which fits inside it. The thimble and pin are both perforated with circular holes lying along a diameter of the thimble (*i.e.*, at right angles to its axis). The copper conductor is passed through these holes, the thimble is inserted into a hole in the web

of the rail, and the flat pin driven in with a blow from a sledge-hammer. The copper conductor—which must be of very soft copper—is thereby bent into the shape of a U, the two limbs of the U fitting into corresponding circular channels (one on each side of the flat pin) in the thimble. The latter is expanded and forced tightly against the sides of the hole in the rail. A. H.

1303. *Train Resistance.* **J. B. Blood.** (Street Rly. Journ. 15. pp. 142–145, 1899.)—The author discusses the various formulæ that have been proposed for train resistance. There are three main factors: the resistance of the journals, approximately constant at high speeds; the friction between the rail and track, which varies approximately with the speed; the wind resistance, which is independent of the weight of the train, and which varies as a power of the speed lying between the first and second. The general formula would then be—

$$R = B + WM + A\frac{M^n}{T}$$

where R, M, and T are the resistance, speed, and weight respectively of the train, B, W, and A are coefficients for the journals, rails, and air respectively, and n is an exponent to be determined by experiment.

To the best of the author's knowledge the formula which would represent good practice would be—

$$R = 4 + \cdot 15M + 30\frac{M^{1\cdot 8}}{T}.$$

Curves are shown comparing the various formulæ, from which it is seen that it is immaterial for trains weighing over 200 tons and running at less than 40 miles an hour, whether the exponent of the speed term be of the first or second power. The variation from the curves is less than the accuracy of the experiments among themselves. A. S.

1304. *Good and Bad Incandescent Lamps.* **F. W. Willcox.** (Elect. World and Elect. Engin. N.Y. 33. pp. 337–340, 1899.)—The most prominent physical defects are loose caps or bases, bad connections in base, poor vacuum, and spotted or discoloured filaments. The last defects can be detected by examination of the lamp filaments by light, when they should reveal a smooth, solid, dark grey surface, and by burning the filament at a dull red, when it should show up thoroughly uniform and free from any dark or bright spots. Batches of lamps, of which more than 10 per cent. are defective as above, should be rejected. W. G. R.

1305. *Silicon Carbide "Premier" Incandescent Lamp.* (Electrician, 42. p. 690, 1899.)—This lamp, called the "Premier," was

invented by Langhans, and is now being introduced by the Premier Electric Lamp Syndicate of Liverpool. The first part of the process of manufacture consists in the treatment of cellulose in successive operations with sulphuric acid of varying concentrations, or with both sulphuric and phosphoric acids, by which means a gelatinous semi-liquid substance is obtained with which silicon, in the form of a fine amorphous powder, is incorporated. The semi-liquid mass of cellulose and silicon, after being freed from air-bubbles by rapid rotation in a centrifugal machine, is pressed or squirted through a fine aperture, from which it issues in the form of a continuous thread, which, passing through alcohol into water, hardens in the usual way. The thread is washed, wound on frames to dry, and carbonised in the ordinary manner, except that, in order to protect the silicon from any nitrogen which may be present, the forms on which the thread is wound are surrounded by a mixture of carbon powder and titanic acid; and that the highest temperature attainable must be held for a sufficient time for the silicon and the carbon formed from the cellulose to combine. The filaments are then "flashed" in a vapour of carbon and silicon.

Owing to the refractory nature of these filaments, they can be run at a higher efficiency than is possible with any carbon filament; they are also claimed to be free from falling off of the light and blackening of the bulbs as time goes on. E. C. R.

1306. *A.B.C. Arc Lamp.* (Elect. Rev. 44. pp. 198–201, 1899.) —This is a new arc lamp, and the following advantages are claimed for it: cheapness and simplicity of construction; adaptability to all circumstances and uses; total absence of mechanism; instantaneous striking of the arc; absolute steadiness of the light; impossibility of extinction; great efficiency of candle-power per unit of current; saving in carbon (45 per cent.); increase of light (20 to 30 per cent.); long burning, and consequent saving of labour.

The frame of the A.B.C. lamp is composed of two brass tubes, the extremities of which are provided with flanges of the same metal, and these are fixed to two cross-pieces. Each of these tubes is surrounded by a solenoid encased in a wrought-iron shield, which is itself closed at each end by an iron washer. Two chains run over pulleys and support at one end the upper carbon-holder, whilst the other ends of the chains are attached to the cores of the solenoids, which are rigidly attached to the lower carbon-holder. The regulation is performed by the attraction of the solenoids on their cores and by gravity. The superiority in illuminating power is produced by the addition of a mantle which is rendered incandescent by the arc. The mantle is said to be unalterable, and to resist the highest temperatures.

W. G. R.

1307. *A 95-Volt Arc Lamp.* **A. D. Adams.** (Elect. Engin. N.Y. 27. p. 222, 1899.)—In a form of enclosed arc lamp working on 110-volt mains at the Boylston Café, Boston, Mass., U.S.A., the regulating coils are shunted by an induction coil. This causes every change in pressure and current at the arc to be opposed by the inductive action of the coil. Thus a much larger percentage of the line pressure is available at the arc, which in this lamp burns regularly at 95 volts. Comparative tests of this lamp and an enclosed arc lamp working with 78 volts at the arc, gave the following results :—

	Long Arc.	Short Arc.
Volts at main	110·	110·
Volts at arc	95·3	78·1
Amperes	4·19	4·12
Watts to lamp	461·	452·
Watts to arc	398·	322·
Mean spherical C.P.	128·	91·3
Watts per spherical C.P. lamp	3·59	4·96
Watts per spherical C.P. arc	3·11	3·50
Gain in efficiency in lamp	27 per cent.	
Gain in efficiency in arc	11 per cent.	

One spherical C.P. cost 27 per cent. less from the mains.
One watt taken by lamp will give 35 per cent. more light.

C. K. F.

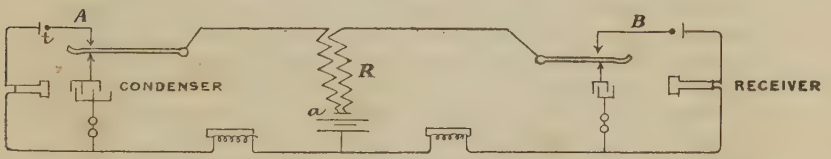
1308. *Volta Arc Lamps.* **W. Wedding.** (Elektrotechn. Ztschr. 20. pp. 65–69, 1899.)—Volta lamps can be worked three in series on 110-volt circuits. Curves and tables are given showing the distribution of the light and comparative cost of working. No particulars are given of the construction of the lamp. C. K. F.

TELEGRAPHY AND TELEPHONY.

1309. *Rowland's Multiplex Printing-Telegraph.* (Elect. Engin. N.Y. 27. pp. 248–249, 1899.)—The apparatus is intended for eight simultaneous messages—four each way—when the instruments are duplexed. Trials were made on an artificial cable, equivalent in resistance and capacity to 1,500 miles of *land-line*, of total capacity 23 microfarads. Photographs of the sending and receiving instruments are given in the article, but further description is reserved. R. A.

1310. *Bell's Selenium Transmitter.* (Elect. Engin. N.Y. 27. p. 223, 1899.)—The voice causes a balance-arm to vary a resistance in series with a low resistance glow-lamp at a red heat. A strip of selenium is illumined by this lamp and is in series with a battery and the line. M. O'G.

1311. *Centralised Sources of Energy in Telephone Exchanges.* **K. B. Miller.** (Elect. World, 33. pp. 178–179, 1899.)—The system of H. V. Hayes of the American Bell Co. in 1892, which is rapidly spreading, is described:—



It will be seen from the figure that fluctuations in the transmitter B affect the coil R and act inductively on the circuit of transmitter A. Stone's method, involving a secondary cell at each subscriber station, is described. H. M. Crane's cord circuit relay is described and the credit of the development of these methods ascribed to the engineers of the Bell and Western Electric Co. (See 1899, Abstract No. 972.) M. O'G.

1312. *Weber's Telephone Call-Check.* (Elekt. Runds. 16. pp. 105–106, 1899.)—This apparatus (German Patent 98857), due to R. Weber, is intended to put a time-limit on the users of telephones at public call-offices, and to indicate the number of such periods taken up by a user. It is arranged so that an unanswered "call" is not recorded. The apparatus consists of clockwork actuated by a toothed-quadrant to which motion is communicated by a falling rod. In its normal position the rod is held down by the weight of the telephone. When the tele-

phone is removed from its hook, the rod begins to be drawn up by a spring, the toothed quadrant comes into gear with the clock work, and the motion is recorded on a dial. If the telephone is replaced before the last tooth of the quadrant has been reached, no permanent record is made; the period is adjusted so as to be long enough for a subscriber to "get on," but not long enough for conversation. When the telephone is kept off the hook for a longer period, the electrical connections are automatically thrown off by the quadrant, and each resetting of them is indicated.

R. A.

1313. *Scribner's Telephone Connection Counter.* (Elect. Engin. N.Y. 27. pp. 108–109, 1899.)—Each telephone line is provided with an answering jack and a line jack. The counter only operates in response to the call at the called substation through the agency of the registering contact pieces of the answering plug and answering jack only. Details of connections are given.

The system is due to C. E. Scribner. M. O'G.

1314. *New York Telephones.* **M. Loewenthal.** (Elect. Engin. N.Y. 27. pp. 142–147, 1899.)—The rent for unlimited distant service is from £7 16s. to £16. The new Exchange (Syracuse) supplies 2,000 subscribers. It is built on the multiple-common-battery-branch-terminal-metallic system. The intermediate frame, relay coil racks, switchboard, power plant, and fire alarm are described. The resistance of trunk line relays is 30 ohms. The double wound relays operate with 0·1 ampere through both windings. The ringing circuits are 200 ohms. The operator's set has 600 ohms, the capacities are 2 mfds. each. There are besides three toll and distance boards. The time of a conversation is recorded on calculagraphs previously described. M. O'G.

SCIENCE ABSTRACTS.

PHYSICS AND ELECTRICAL ENGINEERING

SEPTEMBER 1899.

GENERAL PHYSICS.

1315. *Surface Tension by Ripples.* **L. Grunmach.** (Verh. Deutsch. Phys. Gesell. 1. pp. 13–22, 1899.)—The surface tension of liquids and of molten metals is determined by observing the interference waves produced by two vibrating centres connected respectively to the two prongs of a tuning-fork. Some of the results are given in the following table :—

	Temp. C.	Sp. G.	Surface Tension in Grammes per Centimetre.
Wood's alloy	145°	9·52	0·345
Rose's „	145°	9·34	0·350
Lipowitz's alloy	160°	9·58	0·334
Tin-lead „	215°	8·05	0·394
Tin	240°	6·988	0·359
Lead	335°	10·645	0·482

A. Gs.

1316. *Torsion.* **H. Bouasse.** (Journ. de Physique, 8. pp. 241–252, 1899.)—Confining himself to a loaded wire, the author lays great stress on the fact that the torsion produced by a given couple depends very decidedly on the mode of variation of the torsion with respect to time. Experiments which do not take the time into account are of little utility.

He shows how the behaviour of wires of the same material, but of different diameters, can be compared. Let R = radius of wire, α = angle of torsion, C = couple, t = time. Let θ be defined by the equation $\theta = R\alpha$. "Take wires of the same material, and of different diameters. Load them with weights proportional to their cross-sections. Give them any torsions whatever, α, in the inverse ratio of their radii, in such a way that, for all, the variable, $\theta = R\alpha$, has the same value. This determines that $d\theta/dt$ is the same at each instant for all.

"Drawing curves with $F=C/R^3$ as ordinates, and $\theta=R\alpha$ for abscissæ, however complex they may be, they reduce to a single one for all the wires. If the equation to the curve be $F=\phi(\theta)$, then $C=R^3.\ \phi\ (R\alpha)$, applies to all the curves. Obviously there are as many curves as there are functions, $\theta=f_1(t)$, chosen."

A. Gs.

1317. *Flexibility of Baked Marble.* **P. Gamba.** (Roma R. Accad. Lincei Atti, 8 pp. 264–269, 1899.) The flexibility of marble at the ordinary temperature is measured (see 1899, Abstract No. 641); it is then heated to a higher temperature (100°–300° C.) for a few hours, and afterwards allowed to cool slowly to the original temperature. The operation augments the flexibility, the augmentation increasing with the temperature and with the duration of exposure. The residual deformation is also increased. A. Gs.

1318. *Source of Energy in Diffusive Connection.* **A. Griffiths.** (Phil. Mag. 47. pp. 522–529, June, 1899.)—Following up the work described in Abstract No. 406 (1899), the author here examines the source of energy of the convection in question, and traces it to the change of energy in the form of heat. E. H. B.

1319. *Apparatus for Determination of Rate of Diffusion.* **A. Griffiths.** (Phil. Mag. 47. pp. 530–539, June, 1899.)—This paper describes the apparatus it is proposed to adopt for the determination of the rate of diffusion of solids dissolved in liquids, and examines in detail the probable order of magnitude of the errors to which the apparatus is liable. E. H. B.

1320. *Van der Waals' Thermodynamic Theory of Capillarity.* **G. Bakker.** (Zeitschr. Phys. Chem. 28. pp. 708–718, 1899.)—The principle of thermodynamical equilibrium, due to Gibbs, may be enunciated thus: A substance arranges itself in a given space in such wise as to make (with given energy) the entropy a maximum. Gibbs states this principle in four different forms. Van der Waals, in his theory of capillarity, chooses the form which affirms that, at given temperature, $\int\rho(\epsilon-\tau_1\eta)\ dk$ is a minimum where ρ is the density, dk the volume element, and τ_1 the temperature. The views of Van der Waals on this subject induced the present author to refer the problem of capillarity to purely statical and dynamical principles, and he thus obtains the same fundamental equation as was derived by Van der Waals by means of the principle of Gibbs.

E. H. B.

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available for re-exposure. If ozone is thus able to destroy a latent image, the author concludes that it should be able to restore a fogged plate. The assumption is that ozone oxidises the silver compounds which light has reduced. Two dry plates were wrapped one half of each in tin-foil, and then exposed to brilliant sunlight for two seconds. They were then taken into the dark-room and ozonised for four minutes. Subsequently they were used, with the tin-foil removed, to obtain a Röntgen photograph. The image was visible on the whole surface; the two halves of the plate were, however, not equally transparent. R. A.

1336. *Monochromatic Light as a Damped Vibration.* **A. Rovida.** (Rivista Scientifica, 30. pp. 225–236, 1898.)—In the classical theory of light, each colour corresponds to a definite frequency and to a linear strip of the spectrum: indices of refraction for each colour correspond to the particular frequencies: and white light is a summation of simple colours. Garbasso in 1894 (Atti R. Acc. Sci. Torino, vol. xxx.), considering the Hertzian phenomenon of multiple resonance, reached the conclusion that while monochromatic light may be a simple vibration, white light may be a vibration damped in function of the time. The author rejects the former part of this conclusion. Damping as a function of the displacement was introduced by Helmholtz to explain anomalous dispersion. If we regard monochromatic light as doubly damped, thus—

$$A\,.\,.^{(k+h\sqrt{-1})y+(l+m\sqrt{-1})t}_{\varepsilon}$$

compound light remains the sum of the different colours, depending on the squares of the amplitudes, and the only lights capable of interfering with one another are those of the same colour In the spectrum, the "line" for each colour must still have some breadth, else (Galileo) it would not be visible; but this points to continuous damping in function of time or of displacement. The former of these, expansive damping, when considerable, gives Lommel's results as to widening of spectral lines: the latter, dispersive damping, gives rise to anomalous dispersion. Neither of these can, however, be completely suppressed. The alleged continuity of the spectrum is analogous to the imaginary continuity of water in hydrodynamics. Hertzian waves are given out with single wave-lengths (Hertz, Bjerknes, Le Royer, Berchem), but the resonator shows multiple resonance, which is analogous to a broadening of a spectral line. The impression on the eye seems to show that harmonic vibration, coexisting, may affect the colour-sensation produced: and anatomical peculiarities, pointed out by von Helmholtz, may be explained on the basis of the closest analogy between the ear as a receptor for sound and the eye as a receptor for light: the analogue of the organs of Corti being the

various component fibrillules of the rods and cones of the retina. These would have, in any case, to be extremely slender in order to meet the requirements of the short wave-lengths : and if independent they would be too fragile ; so that, being bound together, they hamper one another's independence of action and fall short in resolving power. But the greater the brightness the greater would be the disturbance of the fibrillules not primarily sensitive to the wave-lengths of the incident light, which would affect the resultant colour-sensation up to the standard of white light. Such a receptor would manifest multiple resonance analogous to that of Hertzian waves. This does not necessarily affect Young's theory of three primary colours. A. D.

1337. *Width of Slit in Interference Experiments.* **J. Walker.** (Phil. Mag. 46. pp. 472–478, 1898.)—A mathematical investigation. The angle subtended by the slit at the interference apparatus must be a small proportion of that subtended by the width of the bands at the same point. When the variations of the width of the bands are due to variations of the distances of the slit and screen of observation from the apparatus, as the bands become finer the slit may be made wider without loss of distinctness. A progressive widening of the slit causes a periodic disappearance of the bands, the system of bands at the successive reappearances being alternately bright and dark centred. A. D.

1338. *Thickness of the Black Spot in Liquid Films.* **E. S. Johonnott, Jr.** (Phil. Mag. 47. pp. 501–522, June, 1899.)—In the work here described two methods suggested by Michelson were used, one by an interferometer, the second, photometric. The author concludes (1) that the thickness of the black film of a soap solution may vary between 6 $\mu\mu$. and 40 $\mu\mu$. (where $\mu\mu. = 10^{-6}$ mm.) ; (2) that the film of a pure oleate solution may consist of two black films, the thickness of the second being about half the limiting thickness of the first, which is about 12 $\mu\mu$. E. H. B.

1339. *Polarisation of Diffused Light.* **A. Lafay.** (Annal. Chim. Phys. 16. pp. 503–562, 1899.)—The researches were suggested by the work of de la Provostaye and Desains upon the diffusion of heat. In order to complete the results obtained with heat rays they studied the action of dull surfaces upon natural and upon polarised light. Generally speaking, the light obtained by the diffusion of a polarised beam presents the character of a mixture of natural and elliptically polarised light, in which the proportion of the latter may attain a considerable value. The

diffusing bodies may be divided into two classes. One of them, represented by glass and dull metals, diffuses light by virtue of the roughness of the surface. The other, represented by marble and porcelain, diffuses light in addition through partial absorption and emission by particles suspended in a transparent mass. The author has concentrated his attention upon the first class as offering simpler phenomena. He gives a method of comparing the state of polish of different surfaces, based upon the smallest angle of incidence at which the surface will produce a clear reflected image. He finds that MacCullagh's relation, viz., $\sin \delta \tan 2\gamma = \text{const.}$, which applies to reflection by a polished metal, has its counterpart in a similar relation in the case of diffused reflection. E. E. F.

1340. *Magneto-Optic Phenomena.* **E. Ketteler.** (Wied. Annalen, 68. 1. pp. 125–128, 1899.)—The author explains the phenomena observed by Macaluso and Corbino, and by Becquerel, by the mathematical theory of magneto-optic phenomena worked out by him as long ago as 1882. That theory did not, however, comprehend the cases observed by Zeeman, and the author acknowledges that the more comprehensive Hertzian equations are required for effectively dealing with the latter. E. E. F.

1341. *Zeeman Effect.* **A. Righi.** (Roma R. Accad. Lincei Atti, 8. pp. 325–326, 1899.)—Fitzgerald suggests that a circularly polarised ray sent through a powerfully absorbent gas should render it appreciably magnetic—a sort of converse Zeeman effect. The experiment is not novel, having been made by the author in 1883, and by Gray in 1890. The author has tried bromine and gaseous N_2O_4, which give Zeeman effects at ordinary temperatures; but there is no trace of a magnetic field, at any rate as powerful as 10^{-6} C.G.S. unit. A. D.

1342. *Zeeman's and Faraday's Phenomena.* **W. Voigt.** (Göttingen, Nachrichten, 4. pp. 329–344, 1898.)—Faraday's magnetic rotatory polarisation and Zeeman's phenomenon are related in this way, that when we consider the inverse Zeeman phenomenon of alteration of selective absorption of a body in the magnetic field, the Faraday effect is found to depend on the relative velocities, while the inverse Zeeman effect is found to depend on the relative absorbabilities acquired by the two oppositely rotary circularly polarised components of natural light traversing the field; so that the inverse Zeeman phenomenon is nothing other than the Faraday phenomenon in substances possessed of selective absorption. In the case of light crossing

the lines of force this relation seems to disappear, for the Faraday effect in this case is apparently absent. The author develops mathematically an explanatory theory of which the Faraday and the Zeeman effects work out as special cases, provided that the Faraday phenomenon in respect of rays across the line of force is not null but produces a very slight ellipticity of the incident plane polarised light. A. D.

1343. *Sodium Vapour in Magnetic Field.* **W. Voigt.** (Göttingen, Nachrichten, 4. pp. 355–359, 1898.)—Sodium vapour in a magnetic field becomes double refracting in directions normal to the lines of force, in a way which may be predicted from the author's explanation of the Faraday and Zeeman phenomena. (See preceding Abstract; also 1899, Abstract No. 999.) A. D.

1344. *Anomalous Dispersion.* **Rayleigh.** (Phil. Mag. 48. pp. 151–152, July, 1899.)—The author shows that Maxwell had considered this question as early as 1869. Maxwell's results are given in a question set in the Math. Tripos examination for that year at Cambridge. He supposes a medium whose elasticity is defined as follows, viz., a tangential displacement η in direction y of a stratum of thickness a calls into play a force of restitution $E\eta/a$ per unit area. Then a system of atoms of other matter such that every part of the medium is connected by an attractive force varying as the distance, and there is also a resistance between the medium and the atoms varying as their relative velocity, the atoms being independent of each other. Hence is obtained the equation of propagation of waves in the compound medium. Let σ be the density of the atoms per unit volume, ρ that of the medium; also let $\sigma p^2\zeta$ be the attraction, and $\sigma R d\zeta/dt$ the resistance; then, if σ be very small, the result given is $\mu^2=\frac{v_o^2}{v^2}=1+\frac{\sigma}{\rho}\frac{p^2}{p^2-n^2}$ where n denotes the periodic time, and v_o the velocity when $\sigma=0$.

S. H. B.

1345. *Spectra of Hydrogen.* **T. W. Richards.** (Chem. News, 79. pp. 159–160, 1899.)—In a recent paper (Phil. Mag., September, 1898) Hutton recounts some interesting experiments which tend to show that Hasselberg's "white spectrum" of hydrogen really belongs to that substance and not to impurities. One point he was unable wholly to explain—the fact that Cornu and he always obtained a brilliant red four-line spectrum of hydrogen whenever a trace of oxygen was present. The experience recently gained by Trowbridge and the author furnishes the data for an explanation of the matter.

Water vapour under diminished pressure gives the pure red spectrum far more readily than hydrogen itself does, and when aqueous vapour is mixed with elementary gases it seems usually to conduct the electricity by itself. This fact (that water vapour conducts electricity easily) may be accounted for by its heterogeneous molecular constitution, which is more sensitive to electric stress than the homogeneous structure of the hydrogen molecule. Water must have been formed in Hutton's and Cornu's tubes, and this must have been the source of the red spectrum. From the above and other arguments the author supposes the red spectrum is due to dissociated atoms of hydrogen, or to the disturbance in the act of dissociation, while the white spectrum is due to the rupture of polarised particles. It is obvious that only the characteristic lines of atomic hydrogen, not those of molecular hydrogen, could be obtained from water, and these are obtained so easily that the molecular spectrum of water steps into the background. On the other hand, if hydrogen is perfectly dry, the red spectrum requires tremendous heat for its appearance in a state of purity—a circumstance which hypothesis explains simply by ascribing great stability to the polarised molecular structure of the gas. J. B. H.

1346. *Absorption Spectra of Gases.* **P. Baccei.** (N. Cimento, 9. pp. 177–191, 1899.)—Various gases were experimented upon in an iron tube 25 m. long, consisting of several parts screwed together and sealed with marine glue. A beam of light from an incandescent lamp was sent through the tube and twice reflected through it by plane mirrors, so that it traversed it three times, thus increasing the effective thickness of gas traversed to 75 m. Pressures up to 20 atmospheres were used. Carbonic acid showed no trace of an absorption spectrum even at the highest pressure. Neither did nitrogen or carbonic oxide. But acetylene showed a band in the red (6842 to 6815) and several lines in the orange, yellow, and green, the brightest being at 6395. The oxygen lines at A and B were observed at a pressure of 14 atmospheres. In the case of hydrogen sulphide the pressure could not be raised beyond 12 atmospheres, owing to the liquefaction of the gas. But a somewhat feeble band was observed in the red (6735 to 6781). E. E. F.

1347. *Broadening of D-lines.* **H. Wanner.** (Wied. Annalen, 68. 1. pp. 143–144, 1899.)—The author describes a curious spectroscopic phenomenon produced by burning a sodium bead inside a sphere having an inner reflecting surface, but a silvered glass sphere on the outside, which may consist of two hemispherical caps. In the spectroscope the sodium lines appear strongly broadened out, and accompanied by a feeble continuous spectrum

reaching into the green and the red. The lines are also once or twice reversed. A somewhat similar phenomenon may be obtained by placing several Bunsen burners one behind the other, but it is then feebler. E. E. F.

1348. *Energy in the Spectrum of a Black Body.* **F. Paschen.** (Berlin Akad. Sitzber. 22. pp. 405–420, 1899.)—The author refers to experiments made by himself (Wied. Ann. 58. S. 455, 1896, 60. S. 662, 1897), from which it appears that the emission of the "absolutely black body" is represented by Wien's formula—

$$J = c_1 \lambda^{-5} \varepsilon^{-\frac{c_2}{\lambda T}} \qquad (1)$$

in which $J d\lambda$ is the energy of that part of the spectrum between wave lengths λ and $\lambda + d\lambda$, T is the absolute temperature, and c_1, c_2 are constants. Generally for λ^{-5} we might use λ^{-a}. Now Wien obtains the following results: Firstly, that if J_m be the maximum value of J, then J_m varies as the fifth power of the temperature, which is satisfied by making $a = 5$ in (1). Secondly, if λ_m be the wave-length for maximum J, then λ_m varies inversely as the temperature. Thirdly, J/J_m is a function, and always the same function, of λ/λ_m. The author obtains the equation—

$$\log J/J_m = a \log \lambda/\lambda_m + a\,(1 - \lambda_m/\lambda).$$

He compares Wien's results with his own experiments, which are described in the memoir. S. H. B.

1349. *Balmain Luminous Paint.* **L. Kann.** (Phys. Rev. 8. pp. 250–251, 1899.)—In the hope of finding, if possible, a process of recording very short Hertzian waves of 1 or 2 mm., the author experimented with Balmain luminous paint, thinking that the fluorescence caused by light of comparatively short wave-length might be annulled by Hertz rays among other rays of greater wave-length. In this he was not successful, but other interesting radiation phenomena were noticed. Upon a frame of cardboard were mounted strips of different materials which were crossed by other strips. This frame was then placed on a photographic plate in a light-tight box and over it was laid the screen, which for some time (one-half hour to six hours) had been exposed to the direct sunlight. This plate was left in the box for different spaces of time (from one-half minute to a few days). It was found that while the light very easily passed through several layers of white paper it did not pass nearly so easily through black paper. It was, indeed, possible to print on the photographic plate very plainly within half a minute the name on a visiting card enclosed in a very heavy envelope.

Objects placed upon the black paper also showed their contours upon the plate, but only after a long exposure. The different strips referred to above showed different transparencies which, however, have not yet been arranged in any definite succession. Cardboard, wood, and aluminium appeared to be especially transparent. Printed letters on a card were sharply photographed even through a sheet of aluminium.

These effects must be due to the radiation of the Balmain paint and not to the vapours of the materials of which the strips are composed, for the same strips were placed upon a photographic plate and exposed five days without obtaining any blackening of the film. Some of the results, it is true, might be explained by the transparency of some of the strips to the rather intense visible light emitted by the screen, but further experiments showed that screens which had been kept in a dark room for one or two days, although the luminosity ceased after five to six hours, gave essentially the same results. E. E. F.

1350. *Change of Absorption produced by Fluorescence.* **J. Burke.** (Phil. Trans. 191. pp. 87–104, 1898.)—An account of experiments which show that fluorescent bodies absorb differently, according as they are fluorescing or not, the rays which they give out whilst fluorescing. When light from a body B, which is fluorescing, is caused to fall upon a similar body A, the amount of light apparently transmitted by A is very different according as A is fluorescing or not, the amount in the experiments described being very much less, only about one-half, when fluorescence is taking place than when the body is unacted upon by exciting light. The amount of fluorescent light given out by A does not appear to be increased or diminished by the incident radiation from B, but an increased direct absorption occurs.

J. J. S.

1351. *Therapeutic Use of Crookes Tubes.* **F. de Courmelles.** (Paris Soc. Franç. Phys. Bull. 123. pp. 2–3, 1898.)—Experiments shown as to medical exploration, of cavities of the body or otherwise, by radiophotography rendered painless by putting the bulb of the Crookes tube to earth so as to limit the electric field. The tubes also last longer and are more readily worked.

A. D.

1352. *Transformation of Röntgen Rays.* **R. Malagoli** and **C. Bonacini.** (N. Cimento, 9. pp. 279–295, 1899.)—The authors have concluded that different substances may be divided into three groups: A, those which act as simple diffusers of

incident Röntgen rays; B, those which act as transformers of these rays; and A-B, bodies which act partly in both these ways. Sagnac, on the contrary, concludes that all bodies belong to group B, and that there is no diffusion of Röntgen rays; that the rays transformed by different bodies differ in their penetrative power and also in their absorbability by air; and that Röntgen rays after transmission through a body are always accompanied by some transformed rays. This paper is devoted to a consideration of the advantages of the authors' photo-plate method of working, as against Sagnac's electroscope method; to a detailed criticism of Sagnac's methods and results; and to a re-affirmance of their former proposition, to which in fact Sagnac has recently approximated. They say there is no evidence that transformed rays are absorbed by air at all; that it has not been conclusively shown that there is any appreciable difference in kind between the incident fasciculus and that disseminated by any body, and that if there be it has not been shown that this is due to a transformation of all the rays rather than of some of them. A. D.

1353. *Deflection of Röntgen Rays behind an Obstacle.* **R. Malagoli** and **C. Bonacini**. (Roma R. Accad. Lincei Atti, 8. pp. 296–302, 1899.)—A critical summary. Conclusion, that there is no true deflection, the apparent deflection being due to diffusion or to secondary rays by transformation. A. D.

HEAT.

1354. *Permanent Changes and Thermodynamics.* **P. Duhem.** (Zeitschr. Phys. Chem. 28. pp. 577–618, 1899.)—The author discusses the properties of systems which depend on a single normal variable, with especial relation to the rupture of elastic bodies. In his first chapter he deals with systems which are defined by a single normal variable besides temperature, to which class belongs sulphur treated of in his former work (Zeitschrift, 23, 193). Systems may be of the first or second kind, the first kind consisting of those whose natural conditions are permanent. He investigates isothermal cyclic processes, expressing the result by curves on the diagram on which the external conditions are defined by the abscissæ; and the distinction is shown between bodies of the first and of the second kind. The second chapter, concerning the rupture of elastic bodies, deals with systems which may belong in part to the first and in part to the second kind. He discusses (1) the form assumed by the lines defining the state of an unstretched wire when the wire is stretched; and (2) the rupture of a stretched wire, referring to works by Dufour, Poucelet, and Kennedy. S. H. B.

1355. *Joule-Thomson Thermal Effect.* **E. F. J. Love.** (Phil. Mag. 48. pp. 106–115, July, 1899.)—The results obtained by Kelvin and Joule in their classic experiments have hitherto been utilised almost exclusively for determining the relation between the various gas scales and the absolute, or work, scale of temperature. The present paper deduces from the same results other consequences. If the ordinary Boyle-Charles equation of a perfect gas be differentiated, it can be at once shown that the Joule-Thomson effect is zero, which is disproved by the experiments. If, on the other hand, Van der Waals' equation—

$$\left(p+\frac{a}{v^2}\right)(v-b)=RT, \qquad (1)$$

be taken as the characteristic of a gas, it can be shown that

$$\theta=\frac{\alpha}{T}-\beta \qquad (2)$$

where θ is the Joule-Thomson cooling effect per atmosphere, T is the absolute temperature, α and β are constants. This is exactly the formula proposed by Rose-Innes, from an examination of the experimental results of Joule and Kelvin, but is here seen to be deducible from Van der Waals' equation. The author also shows that the following relations hold: (1) The Joule-Thomson effect is zero for every substance at its maximum density, just as it is

for an ideal perfect gas, though for a very different reason; (2) the *infinite number* of specific heats which every substance possesses is reduced at this point to *one*. E. H. B.

1356. *Thermal Conductivity of Water.* **S. R. Milner** and **A. P. Chattock.** (Phil. Mag. 48. pp. 46–64, July, 1899; Rep. Brit. Assoc. p. 808, 1898.)—Heat is generated by the passage of an electric current through a platinum wire resistance threaded in zigzags on a mica disc so as to cover the flat circular bottom of a vessel which is separated by a layer of liquid, of easily varied thickness, from the flat top of a copper vessel through which cold water continuously flows. This bottom is made of thin microscope cover-glass which is covered on top with tinfoil cut in concentric rings and insulated by paraffin waxed paper from the heating grid: the distribution of heat-flow is thus equalised and lateral flow prevented without the use of an excessive thermal resistance. All temperatures are measured thermoelectrically, and to ensure that all the heat from the grid flows downwards the grid is packed above with cotton-wool with a compensating coil, the temperature of which is kept always the same as that of the grid. The method of measurement employed is differential. If θ_1, θ_2 are the differences of temperature between the grid and the copper vessel for thicknesses x_1, x_2 of the intervening liquid when C is the current flowing, R and A being the resistance and area of the part of the grid used, then the thermal conductivity is given by

$$k = 0{\cdot}2406\ (C^2R/A)\ (x_2 - x_1)/(\theta_1 - \theta_2).$$

For greater exactness two apparatus of exactly similar make were employed, which were first adjusted to give the same value of θ_1, and the reading θ_2 of one of them which was altered was then compared with the reading θ_1, given simultaneously by the other, which remained unaltered. For further details the paper must be referred to. The final mean value of k for water at 20° C. was found (see an erratum) to be 0·001433 C.G.S. unit. R. E. B.

1357. *Thermal Conductivity of Cast Iron.* **E. H. Hall** and **C. H. Ayres.** (Amer. Acad. Proc. 34. pp. 283–308, 1899.)—By experiments on a disc of 10·06 cm. radius and 1·787 cm. thickness, with temperature-differences measured thermoelectrically, the thermal conductivity of the cast iron used (the analysis of which gave about 3·50 carbon, 0·53 manganese, 0·056 phosphorus, 0·053 copper, 0·106 sulphur, 1·40 silicon) appears to be 0·1490 at 30° C., and to have a temperature-coefficient between 20° and 75° of −0·0010 if the specific heat of water is taken to be constant, but of −0·00075 if Winkelmann's rule for the variation of the specific heat of water with temperature is correct.

The electric conductivity of this cast iron is about 112200 C.G.S. units at 17·4°, with a temperature-coefficient of −0·00118 between 17° and 67°.

The paper contains full details of the method employed and the precautions necessary, as well as an appendix in which the determination of the thermoelectric quality of the cast iron relatively to copper is described. R. E. B.

1358. *Thermal Insulation.* **W. Hempel.** (Wied. Annalen, 68. 1. pp. 137–138, 1899.)—The author compares the Dewar vacuum insulator with some of the older types of thermal insulators, by immersing test tubes filled with a mixture of ether and solid carbonic acid in them, and finding how long they maintain the test tubes at −79°. The improved Dewar tube, silvered on the outside, gave of course the best results, the temperature being still as low as −70° after eighty-eight minutes. Less exhausted vacuum tubes allowed it to rise to −33° in the same time, while tubes packed in wool, cotton, or silk showed −45° to −55°. Eiderdown proved itself a very good insulator, as it kept the temperature down as low as −66°. E. E. F.

1359. *Conduction of Heat in Air.* **Rayleigh.** (Phil. Mag. 47. pp. 314–325, 1899.)—This is a mathematical paper, in Fourier form, dealing with the conduction of heat in air confined by walls at constant temperature, the circulation due to gravity being neglected and also the inertia of the motions due to local expansions and contractions, so that the pressure at any moment is taken as uniform throughout the mass. It is thus given by

$$p = k\rho\,(1 + s + a\theta),$$

where s is the condensation and θ the excess of temperature, with the proviso that these variables are of the form $s = \sigma \exp(-ht)$, $\theta = \tau \exp(-ht)$, where σ, τ are independent of the time t and are connected by the relation $\sigma + a\tau = \text{const.}$ The equation to integrate is

$$\dot{\theta} - \dot{s}\,(\gamma - 1)/a = \nu\nabla^2\theta - q\theta,$$

where γ is the ratio of the specific heats, ν the thermometric conductivity, and q the radiation-coefficient, the radiation being supposed to be proportional to θ; and it at once reduces to the form

$$\nabla^2\tau + m^2(\tau - c) = 0.$$

The author works out three cases: (1) when there is no conduction, or $\nu = 0$; (2) when the gas is enclosed between parallel planes with symmetry on the two sides of the mid-plane, the

simple case corresponding to no radiation, or $q=0$, being completely solved; (3) when the enclosure is spherical, surface harmonics and Bessel's functions being now involved in the solution; in this last case the term of zero order in spherical harmonics (*i.e.*, that characterising symmetry about the centre) is specially considered and is fully developed for $q=0$. R. E. B.

1360. *Liquid Air.* **F. Dommer.** (Revue Scientif. 11. pp. 385–391, 1899.)—An interesting summary of the methods of obtaining liquid air and of its applications. A. Gs.

1361. *Jena Glass Thermometers.* **H. Lemke.** (Zeitschr. Instrumentenk. 19. pp. 33–37, 1899.)—Investigation, with tabulated results, as to the corrections requisite in mercury thermometers of Jena glass 59^{III} between 100° and 200°. A. D.

1362. *Sun's Temperature.* **E. Warburg.** (Verh. Deutsch. Phys. Gesell. 1. pp. 50–52, 1899.)—If a hemispherical surface at $t°$ C. radiates H_t calories per second to a perfectly black area of 1 sq. cm. at 0° C. at the centre of its circular base, the latter will gain $k(H_t-H_0)=s$ cal. per sec. from a part of the hemisphere of angular diameter ϕ. The gain $H_{100}-H_0=h$, may be experimentally found, and the assumption of Stefan's law $H_T/H_0=(1+x/273)^4$ then gives

$$t=273\sqrt[4]{[\{(373/273)^4-1\}\ s/h\,k+1]}-273.$$

Applying this formula to the sun, for which $\phi=0°\ 32'$, and taking for h Kurlbaum's value 0·0176, and for s a value between $\frac{1}{20}$ (Langley's) and $\frac{1}{15}$ (Ångström's), the author finds 6490° C. for the temperature of the sun.

[But he takes $\sin^2\frac{1}{2}\phi$ for k instead of $2\sin^2\frac{1}{4}\phi$, which correction would raise his estimate to 7770° C. The temperature of the firmament, which he calls 0°, is meant to be 0° abs.] R. E. B.

1363. *Dulong and Petit's Law.* **F. Richarz.** (Verh. Deutsch. Phys. Gesell. 1. pp. 47–48, 1899.)—The author has previously shown that in the case of a monatomic gas, such as mercury, the specific heat at constant volume is half the specific heat of the element in the solid state, and it is now pointed out that this relation affords a means of calculating the atomic heat of the solid elements, *i.e.*, the constant in Dulong and Petit's law. The difference between the two specific heats is $C_p-C_v=0·0691/d$, where

d is the sp. gr. of the gas compared with air, and since $C_p/C_v = 5/3$ for a monatomic gas, we have $C_v = 3 \times 0.0691/2d$. But if A is the atomic weight of the gas, $d = A/2 \times 14{\cdot}5$, where 14·5 is the sp. gr. of air compared with hydrogen; hence $AC_v = 3 \times 0{\cdot}0691 \times 14{\cdot}5 = 3{\cdot}006$, the atomic heat of the gas. The atomic heat of the solid element is therefore twice this, or 6·012; but since the specific heats of solids are determined at constant pressure, a slight correction has still to be applied, and the atomic heats of the metals silver, iron, copper, platinum, gold, aluminium, lead, and zinc are thus found to lie between 6·072 and 6·252. N. L.

1364. *Kinetic Theory of Liquids.* **G. Jäger.** (Wied. Annalen, 67. 4. pp. 894–898, 1899.)—The author claims that in all his mathematical papers on the kinetic theory of liquids he avoided coming into conflict with the most salient facts of experimental knowledge. In all kinetic theories certain inaccuracies must necessarily occur, as they do even in the simple relation between the pressure and the volume of a gas. But useful mathematical results may be attained by treating of those elements which have the most essential influence upon the phenomena in question. Voigt's applications of Boyle's law and the law of gaseous friction to liquids leads to results in contradiction with experimental data. E. E. F.

1365. *Kinetic Theory of Liquids.* **W. Voigt.** (Wied. Annalen, 68. 1. pp. 139–142. 1899.)—The author replies to Jäger's criticism of certain details in his application of Van der Waals' theory to liquids. E. E. F.

1366. *Mechanical Equivalent of Heat.* **C. W. Waidner** and **F. Mallory.** (Phys. Rev. 8. pp. 193–236, 1899.)—Recent determinations of the mechanical equivalent of heat by electrical methods have given results differing from those obtained by mechanical means by amounts greater than the probable experimental errors. One object of the present paper is to compare Rowland's results with those obtained by Griffiths, and by Schuster and Gannon.

The thermometers used by Rowland are compared with a platinum thermometer made under the supervision of Griffiths. The latter is also compared with a Tonnelot thermometer, of which an exhaustive study was made by Guillaume some years ago, and from which readings on the nitrogen scale can be obtained. Thus Rowland's readings and the readings of a thermometer of the type used by Griffiths can be brought to the same nitrogen scale.

The electrical methods depend for their accuracy on the knowledge of the E.M.F. of a Clark cell, for which Kahle's latest results give the value 1·4325 volts at 15°. The ultimate conclusions are shown in the following table, the fourth column referring to the nitrogen scale, and being based on the assumption that the E.M.F. of a Clark cell is that already mentioned :—

		Old.	Corrected.
At 15°	Rowland (air scale).....	4·189 × 10⁷	4·187 × 10⁷
	Griffiths (N. scale)	4·198 × 10⁷	4·190 × 10⁷
At 20°	Rowland	4·179 × 10⁷	4·181 × 10⁷
	Griffiths	4·192 × 10⁷	4·184 × 10⁷
	Schuster & Gannon (N. scale) at 19° 1.....	4·1905 × 10⁷	4·185 × 10⁷
At 25°	Rowland	4·173 × 10⁷	4·176 × 10⁷
	Griffiths	4·187 × 10⁷	4·179 × 10⁷

A. Gs.

1367. *Model of Carnot's Engine.* **J. C. Shedd.** (Phys. Rev. 8. pp. 174–180, 1899.)—The author describes a simple model for illustrating the successive operations of the Carnot cycle, and the reversibility, efficiency, &c., of the engine.

W. R. C.

SOUND.

1368. *Pitches of Appunn Pipes.* **F. A. Schulze.** (Wied. Annalen, 68. 1. pp. 99–104, 1899.)—A set of Appunn pipes marked c^5, c^6, c^7, c^8, and c^9 are tested with regard to their pitches by a revolving mirror method (with photographic records), by Kundt's dust figures, and by Quincke's interference method. All these methods gave concordant results, and showed that Appunn's calculated values were not correct. Thus the pipe marked c^9, whose pitch should be 56,800 vibrations per second, actually has a frequency of 10,300, and should therefore be marked fes^6. E. E. F.

1369. *Determination of Pitches.* **C. Stumpf.** (Wied. Annalen, 68. 1. pp. 105–116, 1899.)—In reply to Appunn's criticism of the value of the difference tone method for determining high pitches, the author shows that this method is both convenient and reliable. The discrimination between difference tones of the first order and those of higher orders is not difficult. As long as the primary notes lie within the same octave, there are only two difference tones below the primary notes. The one represents the difference between the two notes sounding together, while the other represents the difference between the higher note and the octave of the lower one. These are distinguished by the fact that as the higher note ascends, the pitch of the first difference tone rises, while that of the second one falls. When the pitches of two high notes to be compared vary very widely, errors are easily made, but these can be eliminated by the use of intermediate pipes. The author believes that the difference tone method is, for the practised ear, the most rapid and accurate for the determination of high pitches. His measurements are confirmed by the objective methods used by Schulze. E. E. F.

1370. *Conical and Irregular Organ Pipes.* **Neyreneuf.** (Annal. Chim. Phys. 16. pp. 562–574, 1899.)—The author tests the influence of a conical addition to a cylindrical pipe upon the note which it emits, or to which it resounds. He finds that if a wider cone is added, the length has as a rule to be increased to produce resonance to the same note, and if a narrower cone is added the length has to be diminished. The nodes are always in the same plane A B, and a maximum or a minimum respectively is attained when the joint between cone and cylinder lies in this plane. E. E. F.

1371. *Cooling of Air and Propagation of Sound.* **Rayleigh.** (Phil. Mag. 47. pp. 308–314, 1899.)—A discussion of the radiating power of air, from which it appears that the cooling of moderate masses of air is not sensibly influenced by radiation. This result deduced from theory is confirmed by experiments on the lines of those of Clément and Desormes, which indicate that the observed cooling (or heating) which occurs can be adequately explained by the conduction of heat from the walls of the vessel, in accordance with the known conductivity of air. In many actual observations on sound the intensity does not fall off in accordance with the law of inverse squares of distances. The author attributes these discrepancies to atmospheric refraction and reflection, and thinks that Mr. Wilmer Duff's explanation (Phys. Rev. vi. 1898) of the attentuation noted in his observations, viz. radiation, is not the true one. J. J. S.

1372. *Radiophone.* (Scientific American, 80. p. 347, 1899.)—An arc lamp is supplied with current, and when the arc is formed a microphone is connected as a shunt to the two carbons through a resistance. The light from the arc is reflected by a parabolic mirror towards a conjugate mirror, at the focus of which is a glass bulb-tube containing granulated carbon. The bulb-tube is connected by an indiarubber tube to an ear-piece. A cornet playing "in front of the transmitter" was heard in the receiver at a distance of 350 feet. [It is not stated whether the effect is as great with the cornet placed behind the transmitter.] R. A.

ELECTRICITY.

1373. *Electrostatic Theorems.* **P. Saurel.** (Journ. Phys. Chem. 3 pp. 232–233, 1899.)—Denoting the electrical energy of a system of electrified points by W, we have—

$$W = \Sigma \frac{q_m q_n}{r_{mn}} = \tfrac{1}{2} \Sigma V_m q_m,$$

q_m, q_n being the charges at the points m, n; r_{mn} the distance between these points; and V_m the potential at the point m.

From this—

$$dW = \tfrac{1}{2} \Sigma V_m dq_m + \tfrac{1}{2} \Sigma q_m dV_m \qquad (1)$$

Considering the work dT done by a small displacement we have—

$$dT = \Sigma \frac{q_m q_n}{r^2_{mn}} dr_{mn} = -\Sigma q_m q_n d\frac{1}{r_{mn}}$$

$$= -d\Sigma \frac{q_m q_n}{r_{mn}} + \Sigma \frac{q_m dq_n + q_n dq_m}{r_{mn}}$$

$$= -dW + \Sigma V_m dq_m \qquad (2)$$

By (1) this becomes—

$$dT = dW - \Sigma q_m dV_m ; \qquad (3)$$

and on adding (2) and (3) we get—

$$dT = \tfrac{1}{2} \Sigma V_m dq_m - \tfrac{1}{2} \Sigma q_m dV_m \qquad (4)$$

There are three cases of interest:—

(1) $dV_m = 0$; when $dT = dW$ (Maxwell's theorem),

(2) $dq_m = 0$; when $dT = -dW$, and

(3) $dT = 0$; in which case $dW = \Sigma V_m dq_m = \Sigma q_m dV_m$.

E. H. B.

1374. *The KR Law.* **W. Moon.** (Elect. Rev. 44. pp. 352–353, 1899.)—The law of current propagation in wires having K capacity and ρ resistance per unit length is $\frac{d^2v}{dx^2} = K\rho \frac{dv}{dt}$ (Fourier).

Blakesley's formula for the general solution for alternating currents is compared to the KR law. Incidentally Blakesley's formula is criticised as leading to $2\sqrt{\frac{\pi}{K\rho\tau}}$ for the wave velocity of electricity, whereas the wave velocity should be less than that

of electricity, just as the velocity of electricity is probably less than that of electromagnetic induction. The Kelvin formula gives $\frac{D}{d} = 1{\cdot}65$ for the best ratio of diameters over the dielectric and over the copper. Blakesley's formula does not, and in this respect the Kelvin formula is probably wrong. M. O'G.

1375. *Loss of Electric Charge by Evaporation.* **H. Pellat.** (Écl. Électr. 18. pp. 481–487, 1899.)—The author gives an account of experiments referred to in Abstract No. 562 (1899). Although the experiments establish the fact that the vapour of an electrified liquid carries off its charge, they equally show that *no electrification of an uncharged liquid can occur by evaporation* —a conclusion contrary to the assumptions made by certain meteorologists. The paper concludes with a discussion of the bearing of the author's experiments on certain known meteorological facts. A. H.

1376. *Leakage of Electricity from Charged Bodies.* **J. C. Beattie.** (Phil. Mag. 48. pp. 97–106, July, 1899.)—This paper is one of a series giving the results obtained on the leakage of electricity from metallic plates covered with various substances when the plates were placed in an atmosphere whose temperature was gradually raised from that of the room up to 250° or 300° C. In the present paper only those experiments are described in which a potential difference of between 80 and 240 volts was used. E. H. B.

1377. *Constitution of the Electric Spark.* **A. Schuster** and **G. Hemsalech.** (Roy. Soc. Proc. 64. pp. 331–336, 1899.)—When a spark passes between metallic electrodes, the spectrum of the metal appears not only in contact with the electrodes but often stretches from pole to pole. It follows that during the spark-interval the metallic vapours must be able to diffuse through measurable distances. An image of the spark is projected on the slit of a spectroscope, and photographs are taken on a film fixed round the rim of a rotating wheel (Dixon's method). The metallic lines are inclined and curved when the wheel rotates, and their inclination serves to measure the rate of diffusion of the metallic particles. The air lines remain straight although slightly widened. Comparing different metals with each other, it is found that those having comparatively low atomic weights, viz., aluminium and magnesium, have high molecular velocities. The average velocity of the aluminium molecule was found to be over three times as great as that of zinc. Cadmium and zinc gave almost identical numbers. Bismuth gave remarkable results. In spite of its high atomic weight some of the lines are but little

displaced, indicating an average molecular velocity of 1,420 metres per second.

The authors are of opinion that the initial discharge takes place through the air: it must do so, because at first no metallic vapour is present. The intense heat generated by the current volatilises the metal, which then begins to diffuse away from the poles. The subsequent oscillations of the discharge take place through the metallic vapours, and not through the air. When the spark is directly focussed on the sensitive film (without interposition of the prism) the photographs show a straight image of the slit followed by a number of curved bands extending from both poles into the spark-gap. The straight image is considered to be the initial discharge through air creating sufficient heat to fill the space with vapour through which the oscillating discharges may then pass. D. E. J.

1378. *Spark Discharge in Solid and Liquid Dielectrics.* **J. Almy.** (Verh. Deutsch. Phys. Gesell. 1. pp. 95–99, 1899.)—The apparatus used in experimenting on solid dielectrics consisted of a spherical metallic electrode 1 cm. in radius, cemented into a vertical glass tube in such a manner that the plane through the ground end of the tube was tangential to the sphere. The end of the tube having been covered with a thin film of oil, the sheet of dielectric to be experimented upon was laid on the end of the tube, and on the top of it was placed a small metal cylinder, which formed the other electrode. The electrodes of this apparatus were connected to an electrometer and an influence machine which was driven by an electromotor. The potential of the insulated electrode was raised slowly by adjusting a point-discharge shunt until a spark pierced the dielectric. The following results were obtained: 1. The discharge potential is about 5 per cent. less when the spherical electrode is replaced by a pointed one. 2. With dissimilar electrodes the discharge potential is but little affected by reversal of polarity. 3. Considerably lower values of the discharge potential are obtained if, instead of raising the potential gradually, oscillations are allowed to take place by connecting an air spark-gap in parallel with the apparatus, and increasing the gap until the dielectric is pierced. 4. The relation between the discharge potential V and the thickness d of the dielectric may be expressed by a linear equation of the form $V=\alpha d+\beta$, where α and β are two constants, the values of which for certain specimens of glass, mica, and paraffin were found to be as follows:

Substance.	α.	β.	Limits of Sparking Distance.
Glass	420	41·5	·04 to ·225 cm.
Mica	18,800	10	·003 to ·006 ,,
Paraffin wax	3,560	17·2	·015 to ·036 ,,

The above values of the constants give the discharge potential

in electrostatic C.G.S. units. 5. In the case of three different specimens of glass and plates of quartz cut parallel and normal to the axis of the crystal, it was found that the order of dielectric strength is the same as that of resistivity.

In the experiments with liquid dielectrics two spherical electrodes, each 2 cms. in diameter, were used. Special precautions were adopted to free the liquid under investigation from foreign solid particles. For this purpose the liquid was filtered under atmospheric pressure through a porous earthenware cylinder into the discharge vessel, which was connected with an air-pump. Further, the liquid was filtered and the electrodes freshly polished after the passage of every spark, as the dielectric strength was found to be seriously impaired (on account of the production of solid particles) by even a single spark, as the following results obtained with xylol (the sparking distance being ·04 cm.) show :—

Conditions of Experiment.	Discharge Potential in Electrostatic Units.
Ordinary clean xylol in open vessel	10–25
Xylol filtered through silk, in open vessel	25–40
Xylol filtered through earthenware cylinder, in closed vessel, and after passage of one spark	55–70
Xylol, before passage of spark, electrodes not freshly polished	80–85
Xylol, before passage of spark, electrodes newly polished	91–93

As is the case with solid dielectrics, a linear relation connects discharge potential with sparking distance, the values of α and β for some liquids being given in the following table :—

Liquid.	α.	β.	Limits of Sparking Distance.
Xylol	1340	40	·01 –·067 cm.
Oil of turpentine	1410	20	·02 –·08 ,,
Petroleum	1920	20·2	·018–·06 ,,
Benzene	1750	21·1	·04 –·055 ,,

These values for the sparking potential are much higher (being in some cases five to eight times as great) than those obtained by Edmondson (see 1898, Abstract No. 923), who, however, did not take sufficient precautions to eliminate solid particles from the liquid. A. H.

1379. *Criterion for Oscillatory Discharge of a Condenser.* **E. H. Barton** and **W. B. Morton.** (Phil. Mag. 48. pp. 143–150, July, 1899.)—In the ordinary theory of condenser discharges it is assumed that the resistance and inductance of the circuit have definite constant values equal to those corresponding

to steady currents. The condition for an oscillatory discharge ($C<4L/R^2$) is modified when we take into consideration the fact that with damped oscillations the current is not uniformly distributed over the cross-section of the conductor. The authors' investigation shows that when this latter fact is taken into account, the critical capacity on the simple theory ($C=4L/R^2$) corresponds in reality to an *oscillating* discharge. This result is contrary to what one would at first sight expect, since it is known that the resistance of a wire is greater, and its inductance less, for alternating than for continuous currents. The explanation of the apparent paradox is to be found in the effect of the *damping* on the *inductance*. The authors show that when the damping becomes great the value of the equivalent inductance is greater than its value for steady currents, there being an *axis*-concentration of the current in the conductor, instead of the usual surface-concentration with undamped oscillations. In this connection the authors remark that from general reasoning it seems clear that, if we think of a rapidly damped disturbance propagated into a wire from its boundary, and if the alternations are slow enough to allow the currents to penetrate to the core, we should expect to find an axial concentration during the latter stages of the phenomenon. A. H.

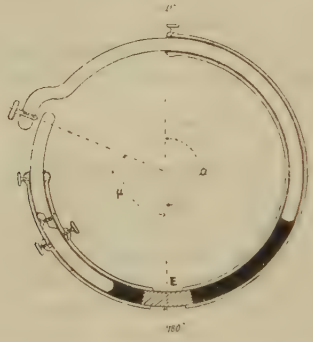
1380. *Anti-coherer.* **A. Neugschwender.** (Wied. Annalen, 68. 1. pp. 92–98, 1899.)—The author attempts to explain the action of the anti-coherer consisting of a gap between metallic deposits on glass bridged by a film of moisture. He finds that the increase of resistance under the influence of electric waves is only observed when the moisture contains a salt, and when that salt is capable, under electrolysis, of separating out pure metal. On sending a current through a gap in a platinum deposit bridged by a drop of silver nitrate solution, minute tree-like structures are seen under the microscope to form at the kathode. These gradually extend across towards the anode, thereby considerably diminishing the resistance encountered by the current. When electric waves impinge upon the gap, sparks proceed from the ends of the branches, and the trees are broken up into small pieces, which appear considerably agitated. On the cessation of the waves the pieces cohere again more or less, and the original conductivity is partially restored. Hence the "self-righting" action observed. The resistance may thus vary between 50 and 90,000 ohms. E. E. F.

1381. *Propagation of Long Electrical Waves.* **M. I. Pupin.** (Amer. Instit. Elect. Engin. 16, pp. 111–160, 1899.)—This paper describes an experimental method of investigating the propagation of long electrical waves, and discusses the mathematical theory bearing upon the same. The theory deals with the following

questions: (1) What variation does the wave energy undergo during its propagation from the transmitting to the receiving apparatus? and (2) What are the means theoretically suggested for measuring the wave-length and the velocity of propagation of the long electrical waves which accompany forced electrical oscillations? In the experiments the electric waves of a frequency of about 1,000 per second were sent along conductors having capacity and inductance so arranged as to represent in the space of the laboratory some miles of a telephone circuit.

E. H. B.

1382. *Resonator with Gap.* **A. Turpain.** (Écl. Électr. 18. pp. 312–313, 1899.)—The author modifies the Hertzian ring resonator by making an ebonite gap at E, and clamping the two portions of the ring in copper tubes, so that the azimuth μ of the spark with respect to the gap may be adjusted within wide limits.



When the position of the ring is adjusted for maximum spark length, that maximum steadily diminishes from 350 to 100 microns as the angle μ is diminished from 180° to 50°. (See also 1898, Abstract No. 512.) E. E. F.

1383. *High-Frequency Experiments.* **N. Tesla.** (Elect. Rev. N.Y. 34. pp. 193–197 and 204, 1899.)—A popular illustrated account of the author's high-frequency experiments, using vibrations of from 400,000 to 800,000 per second. W. R. C.

1384. *Hall Effect in a Binary Electrolyte.* **F. G. Donnan.** (Phil. Mag. 46. pp. 465–472, 1898.)—A calculation showing that the potential-gradient of the Hall effect must bear to the potential-gradient of the primary current a ratio of the order of $16 \times 10^{13} : 1$, and is therefore very easily missed. A. D.

1385. *Contact and E.M.F.* **Q. Majorana.** (Roma R. Accad. Lincei Atti, 8. pp. 255–259 and 302–309, 1899.)—Description of a modified Thomson replenisher, in a simple and a more complex form, the effect of which is to produce a current off a commutator. Calculation as to the approximate E.M.F. required to generate this current. Experiments as to the actual attraction between opposite charges induced by contact E.M.F., and the values calculated for this. A. D.

1386. *Self-Induction Experiments.* **A. G. Dell.** (Elect. Rev. N.Y. 34. p. 207, 1899.)—A self-induction, a voltaic cell (as free from polarisation as possible), a coherer, and a galvanometer are connected in series in the order mentioned so as to form a closed circuit. A key is connected up from a point between the cell and coherer to a point between the self-induction and the galvanometer. On depressing the key so as to close this second circuit, the galvanometer needle is not deflected; but upon breaking this circuit a deflection occurs which depends upon the value of the self-induction. W. G. R.

1387. *Conductivity of Copper in Various Dielectrics.* **J. F. Merrill.** (Phys. Rev. 8. pp. 112–127, 1899.)—The resistances of two similar spirals of copper wire are compared when both spirals are in air and again when one is in air and the other in another dielectric. Platinum thermometers give the mean temperatures of the spirals, and any variations of resistance due to temperature are allowed for. The method used is a very sensitive Wheatstone's bridge arrangement, the two spirals forming two of the arms of the bridge, and a balance being produced by shunting one of the spirals by a variable resistance. All the necessary precautions are taken. The dielectrics used are kerosene, absolute alcohol (both as vapour and as liquid), ether vapour, gasoline, benzene (liquid and vapour), petrolic ether, and chloroform vapour. All the variations noticed were within the limits of experimental error, the maximum being 0·008 per cent. Previous results of Sanford and Grimaldi and Platania are criticised. J. B. H.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

1388. *Explosions Caused by Commonly Occurring Substances.* **C. E. Munroe.** (Science, 9. pp. 345–363, 1899.)—Presidential address to the American Chemical Society. Gives an account of explosions caused by flour dust, zinc dust, by various compounds used in chemical laboratories, by paraffines, benzoline, naphtha, "driers," and by fire-damp in mines. D. E. J.

1389. *Endothermic Gases.* **W. G. Mixter.** (Amer. Journ. Sci. 7. pp. 323–327, 1899.)—A spark or a red-hot platinum wire explodes acetylene gas if at 3 or more atmospheres but not at 2 atmos. pressure. The weak glow discharge does not cause explosion up to 20 atmos. pressure. Admixture of hydrogen prevents explosion to some extent. Partially liquefied cyanogen at about 5 atmos. pressure is not exploded by sparks or by a platinum wire heated to its melting-point. A filament of carbon forms between the wires between which the sparks are passed. Nitrous and nitric oxides are slowly decomposed when sparked under pressure, but do not explode. T. E.

1390. *Non-Explosive Combination of Explosive Gases.* **W. G. Mixter.** (Amer. Journ. Sci. 7. pp. 327–334, 1899.)—Detonating gas, mixtures of carbonic oxide or cyanogen with oxygen, and other explosive mixtures of gases, do not explode when sparked below a certain pressure. A similar statement applies to the explosive decomposition of acetylene. The author concludes that the explosions do not occur in the instances given, because of the infrequency of impacts of molecules having a velocity or internal energy adequate for chemical union. [Van't Hoff gave an adequate discussion of this matter in the Études de Dynamique Chimique, in 1885.] T. E.

1391. *Composition of Mixed Vapours.* **H. R. Carveth.** (Journ. Phys. Chem. 3. pp. 193–213, 1899.)—In order to determine the composition of the vapour evolved by a boiling mixture of two volatile liquids, the mixture is placed in a large flask closed by a cork, through which a glass tube, blown out at its lower end to a small pear-shaped bulb, is passed. The upper part of the small bulb is perforated by several holes, and a platinum wire is sealed through its lower extremity as in Beckmann's apparatus for the determination of boiling-points. A

condenser passes through the cork of the large flask, arranged so that the condensed liquid may flow back into the main body of the solution, or into the small flask through one of the above-mentioned perforations. Both the small and the large flask contain thermometers. When the perforations of the small flask dip below the surface of the solution, both thermometers indicate the same temperature, *i.e.*, the boiling-point of the solution. When the small flask is raised, so that it only touches the solution, and the condensed vapour is allowed to flow into it, this condensed vapour is soon raised to its boiling-point (which is always lower than that of the less volatile, original solution). One thermometer now indicates the boiling-point of the original solution, the other that of the condensed vapour. By taking the quantity of solution large in comparison with the quantity of condensed vapour, the concentration of the former is but little affected by the removal of the latter. When a number of determinations have been made with solutions of known concentration, a curve may be drawn from which the unknown concentration of the condensed vapour may be obtained from its boiling-point. The composition of the vapour evolved from mixtures of carbon bisulphide and benzene is determined by distillation experiments, and the results compared with those obtained by the method just described. In this way an error was discovered, due to the hot vapours from the boiling liquid carrying away some of the more volatile constituent of the liquid returning from the condenser. By modifying the apparatus slightly this was prevented, and results in good agreement with the distillation experiments obtained. T. E.

1392. *Continuous Transition between Solid and Liquid.* **G. A. Hulett.** (Zeitschr. Phys. Chem. 28. pp. 629–672, 1899.)—Some substances such as p-azoxyanisol, p-azoxyphenetol, and cholesteryl benzoate were found by Lehmann to exhibit a curious transition, being transformed, namely, at a certain temperature peculiar to each substance, into liquid phases which still possess crystalline properties. The author investigates the effect of pressure on this transition-point, up to 300 atmospheres. The transition-temperature is found to rise considerably with pressure in all three cases. The heats of transformation at various pressures are calculated by making parallel experiments with solutions of thymol in the aforementioned substances, and applying van't Hoff's formula to the depressions of the transition-points. These values do not agree with the values calculated by means of the Thomson-Clausius formula from Schenck's observations on the volume-changes involved, which discrepancy is shown by the author to be due to the fact that the thymol dissolves in the liquid crystals, so that the original van't Hoff formula is not applicable.

The author measures further the effect of pressure on the transition-temperature of solid-liquid crystals, and is able here to apply the van't Hoff formula, after making parallel experiments with thymol solutions and observing the corresponding depressions. In the case of p-azoxyanisol and p-azoxyphenetol the heat of transformation is found to *increase* with the temperature, indicating a solid-liquid critical point at *negative* pressures.

Similar experiments were made with benzene, p-toluidine, and camphor, where, of course, the liquid phase possesses no crystalline properties. In conclusion the author points out the possibility of the existence of a solid-liquid critical point at *negative* as well as *positive* pressures.

In an appendix are contained similar pressure-temperature determinations for Phenol, Thymol, Naphthalene, Naphtylamine, Benzophenone, Stearic Acid, Crotonic Acid, Nitrophenol, Phosphorus, Menthol, and Monochloracetic Acid. F. G. D.

1393. *Velocity of Crystallisation.* **M. Wilderman.** (Proc. Chem. Soc. 15. p. 175, 1899.)—The rise of temperature accompanying the separation of ice or a salt from supercooled or supersaturated solutions is measured by means of a platinum thermometer, arranged to give a continuous record on a rotating drum. The results may be expressed in the form of an equation, viz., $dt/dz = C\,(t_0 - t)\,(t - t_1 + K)$, where t_0 is the temperature of equilibrium and t_1 the temperature at which the reaction began, and C and K are constants, and z the time. T. E.

1394. *Röntgen Ray Photography and Alloys.* **C. T. Heycock** and **F. H. Neville.** (Journ. Chem. Soc. 73. pp. 714–723, 1898.)—Freezing a dilute solution of permanganate of potash, we have first clear ice crystals, and then solidification of the permanganate with the water. Starting with a hot concentrated solution, crystals of permanganate are first formed, and then the same ice-permanganate solid as in the previous case. A solution can be made, of intermediate strength, which will freeze homogeneously. It is saturated at its freezing-point. With alloys, slow cooling results in crystals or threads, &c., which can be rendered visible by radiographing very thin sections. A series of interesting radiographs accompanies the paper and shows the structure and the variations of this with modes of cooling in alloys of different composition. A. D.

1395. *Metallography.* **E. Heyn.** (Frank. Instit. Journ. 147. pp. 447–463, June, 1899.)—The contribution of Heyn to this subject is translated by Kreuzpointner, and is illustrated by

a large number of photographs of etched surfaces of bronze and steel.

Heyn asserts that the micro-structure of a metal or alloy is dependent only upon the temperature and mechanical treatment to which it has been subjected, but not upon time of etching, as asserted by Outerbridge and Clamer. The reagents used for etching, and the time of such treatment bring into view *different details of the micro-structure*, but they cannot possibly be held to alter the latter. Heyn supports this assertion by details of the examination of a machinery bronze and of a soft steel; the variations in the micro-graphic structure of each of which are shown by the aid of the photographs to be apparent, but not real.

These apparent changes of structure are also shown to be caused at times by variations in the method of photographing the etched surface. They may also be due to variations in the etching power of the reagent used, owing to accumulation of salts of iron in the fluid, at points upon the surface of the metal or alloy. The paper closes with some remarks upon the selection of sections from plates and bars, for submission to the micrographic examination.

Notes are added by Kreuzpointner, Sauveur, and Outerbridge, relating chiefly to the previous contribution by Outerbridge, which called forth Heyn's reply. Kreutzpointner and Outerbridge still contend that the introduction of standard methods in metallography is required before the science can become of practical service in foundries and engineering shops.

J. B. C. K.

1396. *Thermal Effects of Dilution.* **J. H. Pollok.** (Proc. Chem. Soc. 18. pp. 8–9, 1899.)—The author has mixed saturated solutions of various salts with equal volumes of water at the same temperature and found that the temperature sometimes rises, sometimes falls. Seventeen salts are examined, and the changes of temperature, varying from $+0{\cdot}6°$ for $CaCl_2$ to $-1{\cdot}8°$ for $NaNO_3$, are given. T. E.

1397. *Iodine Compounds.* **E. C. Sullivan.** (Zeitschr. Phys. Chem. 28. pp. 523–545, 1899.)—The properties of iodine in iodonium bases, which are shown by conductivity and velocity of saponification to be strong bases, ionised to (nearly) the same extent as soda, differ from those in other compounds. The constants of refractive power of iodine are as follows:—

	R_D.	R^2_D.
In iodides (as ion)	28·3	16·6
„ iodobenzene	25·9	14·1
„ diphenyliodonium	27·9	17·1
„ iodobenzene chloride ...	36·8	18·7

In iodates R is probably less than 22·9. The electric potential of iodobenzene chloride is somewhat less than that of free chlorine; the latter varies with the concentration (in HCl solution) according to Henry's law, whence the molecule is Cl_2. Iodine chloride shows the same potential alone as when mixed or combined with rubidium chloride, hence the same active constituent is shown to exist: the reduction is a univalent reaction; in solution in HCl complex molecules are probably formed, as the depression of the freezing-point and the increase in conductivity are both smaller than if the ICl were hydrolysed to HIO_3 and HCl: iodine is observed to be set free. B. B. T.

1398. *Hydrolytic Dissociation and Thermochemistry.* **G. Platner.** (Elektrochem. Ztschr. 5. pp. 229–232 and p. 247, 1899.)—The figures for the heat of formation, derived from the elements and water, show, according to Platner, no connection with the figures calculated from hydroxide, acid, and neutralisation; but they are in close agreement when we take the hydrolytic dissociation into consideration. In the first paper, the author points out that the nitrates offer particularly instructive examples, inasmuch as the heat of formation of nitric acid is exactly equal to the heat of decomposition of water, so that the two terms eliminate one another. The second paper admits that these two terms differ by 29·84 cal. (98·2 − 68·36); but their difference proves constant for the nitrates of Ag, K, Na, Ba, Mg, Zn, Cd, Cu. The hydrolytic dissociation fails, however, in the case of cyanides. The experiments concern the redetermination of the heat of solution of 25 salts, mostly chlorides, also nitrates, sulphates, &c.
H. B.

1399. *Optically Active Alkyloxypropionic Acids.* **T. Purdie** and **G. D. Lander.** (Journ. Chem. Soc. 73. pp. 862–878, 1898.)—A very great increase in optical activity attends the replacement of the alcoholic hydrogen of lactic acid by an alkyl group; and the greater the weight of the introduced alkyl group the greater is this increase. The increase of optical activity upon dilution is in some cases very great. A. D.

1400. *Optical Activity of Gallotannic Acid.* **O. Rosenheim** and **P. Schidrowitz.** (Journ. Chem. Soc. 73. pp. 878–893, 1898.)—Commercial, so-called pure, gallotannic acid contains varying quantities of gallic acid and of mineral substances, to which latter the great differences in optical activity, ranging from $[\alpha]_D + 11°$ to $[\alpha]_D + 74°.2$, are probably due. The chief constituent is a substance of $[\alpha]_D + 75$. The optical activity slightly increases

with dilution down to 1 per cent. and then remains steady; varies greatly with the solvent employed; and is greatly affected by inactive substances, being depressed by alkalis and by mineral salts. The chemical formula for gallotannic acid, which contains no asymmetrical carbon atom, would appear to be wrong. A. D.

1401. *Rotatory Power of Sugar.* **E. Mascart** and **H. Bénard.** (Annal. Chim. Phys. 17. pp. 125–144, 1899.)—At the request of a commission nominated by the French Minister of Finance the authors have redetermined the concentration of the normal sugar solution employed in saccharimetry. This quantity is the weight of pure sugar contained in 100 cc. of a solution which gives a rotation of 21·67 in a tube 20 cm. long at 20° C., the light employed being that of a sodium flame. The observations are made with instruments of the Laurent type. When the light is filtered through a plate of potassium bichromate the rotations observed are about 0·1 per cent. too small; the addition of a plate of nickel sulphate, however, gives sufficiently homogeneous light. The influence of temperature on the results is carefully examined. The final result is that, at 20°, in solutions containing about 16 grammes per 100 cc., the specific rotation of sugar $[\alpha]^{D}_{20^\circ} = 66{\cdot}54$, and that the normal solution above defined contains 16·284 grammes.

If, in determining the volume of the measuring flask employed in making up the solutions and in weighing the sugar, the weighings are not reduced to *vacuo*, the weight of sugar which must be taken becomes 16·29 grammes. T. E.

1402. *Mixtures of Optical Isomers.* **G. Bruni.** (Roma R. Accad. Lincei Atti, 8. pp. 332–335, 1899.)—Bakkuis-Roozeboom (Berl. Berichte, xxxii. 537) applies solubilities and fusing-points to the determination of the question whether a given mixture of optical isomers contains true racemic compounds, inactive conglomerates, or mixed pseudo-racemic crystals. The author applies cryohydrate phenomena to the same purpose. A. D.

1403. *Ternary Mixtures, IV.* **W. D. Bancroft.** (Journ. Phys. Chem. 3. pp. 217–231, 1899.)—The results of the experiments of Wright, both by himself and in collaboration with Thompson and Leon, on the solutions of a metal, C, in two partially miscible metals, A and B, which are in equilibrium at a given temperature, are here examined. Now if A and B are non-miscible, and C_1, C_2 represent the amounts of the solute C in two

phases in equilibrium which contain respectively A_1 and B_2 of the solvents A and B, Taylor has shown that normally

$$(C_1/A_1)^m \div (C_2/B_2)^n = K,$$

where m, n, K are constants. The author tests the applicability of this formula to the cases under review by plotting the logarithms of the concentrations C_1/A_1 and C_2/A_2, measured in grammes, per 100 grammes of the alloy, as ordinates and abscissæ respectively, the subscript 1 referring to the denser phase, and finds the loci obtained to be fairly linear (justifying the formula) along the greater part of their stretch, though curved for the smallest values of the concentration in the first metal for the systems 6–9 below and also for the largest values of this concentration for the system 9. His results are tabulated below, the values given for K being the means obtained from the author's figures for the approximately linear parts of the stretches.

	A	C	B	Temp. C.	m	n	K
1	Pb	Ag	Zn	750–850	−1·	−1·8	38·9
2	Bi	Sn	Zn	650	1·	1·25	4·30
3	Bi	Cd	Zn	600	1·	0·96	1·76
4	Cd	Sn	Al	700–750	0·92	1·	2·23
5	Bi	Sn	Al	750–850	1·	1·05	1·57
6	Pb	Ag	Al	830–900	−1·	−1·65	242·
7	Bi	Ag	Al	830–900	−1·	−1·43	73·4
8	Bi	Ag	Zn	700–800	−1·	−3·8	10·9
9	Pb	Sn	Al	750–850	1·	1·85	1·24

The curving may be due to experimental error and also to neglect of the effect of the mutual miscibility of the solvent liquids.

It is further found that, with the exception of Cd or Sb in Zn and Pb, the distribution-ratio C_1/C_2, or C_2/C_1, does not exceed 2 for any system not containing Ag; and also that the distribution-ratio for dilute solutions stands in no obvious relation to the reacting weights of the partially miscible metals. R. E. B.

1404. *New Class of Inorganic Acids.* **W. Hittorf** and **H. Salkowski.** (Zeitschr. Phys. Chem. 28. pp. 546–555, 1899.)—The compound $PtCl_4 + 5H_2O$, shown by Jörgensen to be a dibasic acid forming the insoluble salt $Ag_2PtCl_4.O + H_2O$, and by Kohlrausch to conduct well, is investigated in respect to

transference. The Pt and Cl migrate together towards the anode, transference value about 0·13. Gold chloride forms a similar acid, H_2AuCl_3O, transference value 0·23. It is suggested that other acids of this class may be discovered. B. B. T.

1405. *Electrolysis of Mixed Electrolytes with a Common Ion.* **J. G. MacGregor.** (Phys. Rev. 8. pp. 129–140, 1899.)—Schrader, Hopfgartner, and Hoffmeister have electrolysed aqueous solutions containing two electrolytes having a common ion, the object being to determine the effect produced on the ionisation of an electrolyte by the addition of a second. The effect produced was, in some cases, of the kind required by the ionisation theory. The theory may be more satisfactorily tested by determining the ionisation coefficients in the complex solutions, then calculating the relative amounts of the distinctive ions transferred by the current, and comparing these values with those found by experiment. This the author has done, making use of the experimental work of the above observers. The results are reasonably satisfactory for solutions of $NaCl+HCl$, $KI+KCl$, and $BaCl_2+HCl$. In the case of $H_2SO_4+CuSO_4$, the calculated values differ considerably from those obtained experimentally, probably on account of the formation of acid sulphate.

W. R. C.

1406. *Organic Electro-Chemistry.* **M. Krüger.** (Elektrochem. Ztschr. 5. pp. 240–246, 1899.)—This is a continuation of the author's series of historical papers (see 1898, Abstract No. 1185; and 1899, Abstracts Nos. 489 and 868), and relates to the action of electrolytic hydrogen upon organic nitro-compounds, and chiefly upon nitro-benzene under varying conditions. W. G. M.

1407. *Electrolytic Perchlorates.* **F. Winteler.** (Chem. Zeitung. 22. p. 90, 1898; also Ind. Electrochim. 3. pp. 3–4, 1899.)—Perchlorates can be formed by prolonged electrolysis of solutions of the alkali metal, or alkaline earth, chlorides. Platinum electrodes should be used. Chlorates are first formed. When all the chloride has been converted into chlorate, the best conditions for further conversion into perchlorate are: (1) Acidity of the solution at the anode; (2) low temperature of the solution at the anode; (3) a current density of 4 to 12 amperes per square decimetre at the anode; (4) a saturated solution as electrolyte. Under these conditions 73 to 95 per cent. of the oxygen liberated at the anode may be fixed as perchlorate. The electrodes should only have one surface in contact with the electrolyte. The formation of perchlorate is accompanied by that of ozone. Perchloric acid can be formed in a similar manner by electrolysis of hydrochloric acid. J. B. C. K.

1408. *Electrolytic Chlorates, Bromates, and Iodates.* **E. Müller.** (Zeitschr. Elektrochem. 5. pp. 469–473, 1899.)—This process is a result of experiments based on those of Forster and Jorre. The author has found that the addition of a small amount of a chromate salt to the electrolyte enables a very high current efficiency to be obtained without the use of diaphragms between anode and kathode compartments of the cell. Full details are given of the electrolytic apparatus used in these experiments, and of the chemical methods used for determining the electrical efficiency of the process.

The following figures were obtained in experiments, each of which lasted twenty-one hours :—

Sodium Chlorate	...	current efficiency	67·9 per cent.
Potassium Iodate		„ „	97·0 „ „
Potassium Bromate		„ „	89·8 „ „

It was found that platinum formed the best anode material.

The author concludes his paper by presenting two theories to account for the remarkable action of the chromium salt in accelerating the oxidation of the electrolyte. According to the one, a thin film of chromic hydrate is formed over the surface of the kathode, and acts as a diaphragm to protect the oxygen salts in solution from the reducing action of the hydrogen liberated at the true surface of the kathode. According to the second, a film of an alloy of chromium and platinum forms upon the surface of the kathode, and acts in a similar manner.

It was found that chromates give better results than any other oxygen salts, manganates having little or no effect in accelerating oxidation of the electrolyte. J. B. C. K.

1409. *Verley's Method of Treating Syrup with Ozone.* (Ind. Electrochim. 3. pp. 25–29, 1899.)—The ozone generators of Verley are of the Berthelot type. A slab of slate is covered with aluminium. Glass bars 4 mm. thick are fixed on the aluminium ; on these rests a glass plate, silvered on its upper surface. The air circulates in the space between the aluminium and the glass, the bars forcing it to describe a spiral before it escapes through an opening in the centre. In order to obtain electric currents of very high frequency a Hertz arrangement has been adopted. A condenser is placed on the silvered glass, and a spark-gap is interposed in the wire connecting the condenser with the aluminium. Verley works with long sparks, and calls this part of his apparatus the exploder. At Courbevoie he employs 140 such generators in a hall, whose temperature is maintained at 0° C. by means of a sulphurous acid refrigerator, for the production of vanillin, &c. The treatment of beetroot sugar syrup which Bouillaut has introduced at Noyon takes place during the

winter months, so that artificial cooling is not required. The installation for the daily treatment of 200 tons of syrup comprises a 100 H.P. steam engine, an alternator for currents of 300 amperes at 250 volts, and 10 transformers, raising the tension to 12,000 volts, and each feeding 10 ozone generators, 100 altogether. The ozonised air is sucked through a column of coke impregnated with caustic soda for the absorption of the nitrogen compounds, and then through two (of three) sugar ozonisers, each of 70 hectolitres capacity, which are provided with several perforated false bottoms and agitators. The syrup is rendered slightly alkaline by means of lime, and cooled down to 20° C. The ozone is absorbed by the syrup, which turns dark. After about ninety minutes the gas passes freely through the syrup, and the colour becomes lighter again. An after-treatment with sulphurous acid and baryta seems to answer best. The process is stated to give a higher yield of a superior beetroot sugar, odourless and of pleasant taste. H. B.

1410. *Electro-metallurgy.* **E. Andreoli.** (Elektrochem. Ztschr. 5. pp. 236–239, 1899.)—The author deals with the Tommasi lead process (see 1898, Abstract No. 1383), the electro-deposition of nickel, and the Castner-Kellner (see 1898, Abstract No. 962), Hargreaves-Bird (see 1898, Abstract No. 832), and Hulin (see 1898, Abstract No. 417) electrolytic alkali processes. The greater portion of the article is devoted to processes for the extraction and recovery of gold.

The Cassel-Hinman and Haycroft processes are described. The former is non-electrolytic ; the latter depends upon use of a hot solution of sodium chloride, and electrolysis with a mercury kathode. The proposals of Cowper-Coles to use aluminium as kathode in gold-cyanide solutions, and of the author to use lead peroxide as anode material are next dealt with. The cyanide treatment as applied to slimes is discussed, and it is stated that 76,000 tons of slimes have already been reworked in one year at the Robinson Mines. The electrolytic recovery process is considered by the author to be the only one applicable to the cyanide solutions obtained from these slimes on account of their dilution. They contain only 0·4 to 1·5 gram gold per ton of solution. Iron anodes can be safely used for electrolysis of these solutions, since a current density of only 0·03–0·04 ampere per square foot is used, and with this the iron is only slightly attacked. J. B. C. K.

1411. *Trustedt's Magnetic Concentration Plant.* (Elect. Engin. N.Y. 27. p. 221, 1899.)—In O. A. P. Trustedt's recently patented system for the concentration of magnetic materials, a row of electromagnets is excited by polyphase currents so that the magnetic

field moves along from one end to the other, and carries the magnetic material with it. The non-magnetic material is carried away in a transverse direction by a stream of water or air.

W. R. C

1412. *Manufacture of Calcium Carbide with Three-Phase Currents.* **E. Segre.** (Bull. Ass. Ing. El. Liège, 10. pp. 161–186, 1898–1899.)—The author describes a calcium carbide installation at St. Marcel (Italy), which has been erected and designed by the engineer in charge, Mons. Memmo, with the view to using three-phase currents. The raw material is a mixture of wood charcoal and quicklime, intimately mixed and moulded into briquettes. The light weight of this form of carbon renders this necessary to avoid dust, which interferes with the regularity of the arc. The furnaces employed are either continuous or intermittent, and in both cases are of simple form. The three-phase current is introduced into the furnace by three carbon rods, inclined to one another at an angle. There are three arcs, formed either in the form of a triangle between the three carbons, or in the form of a cross between each carbon and a neutral piece of carbon between them. This latter may be connected to the neutral point of the dynamo. By using three-phase current there are less violent fluctuations of the current, as, if one arc fails through some local disturbance in the furnace, the other two arcs continue to employ current and thus prevent an undue strain on the dynamo. The paper includes a detailed description of the 800 H.P. turbine plant, and of the dynamos and electrical fittings designed specially for this method of working. There is also a full account of the working of the furnaces and the results obtained from them. J. L. F. V.

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1413. *Iron-Consuming Batteries.* **A. A. Beadle.** (Soc. Chem. Ind. Journ. 18. pp. 332–333, 1899.)—The author considers the use of iron as the electro-positive element in voltaic cells. He has obtained good results by placing the iron in a porous pot and using ferric chloride as electrolyte. In this way the iron only reduces the electrolyte in the porous pot, that about the carbon being reduced only on closed circuit. The latter part of the electrolyte may be reoxidised by suitable reagents.

W. R. C.

1414. *Harrison Lead Peroxide Battery.* **J. D. Darling.** (Frank. Instit. Journ. 148. pp. 55–65, July, 1899.)—This battery consists of zinc opposed to lead peroxide in sulphuric acid. The E.M.F. is 2·45 volts. The lead peroxide is prepared electrolytically and compressed round a central conductor of lead that has been previously treated in a way that prevents sulphating. The zinc is in the form of a cup attached to an amalgamated copper conductor: this cup is filled with zinc amalgam which is solid when cold. When voltaic action takes place, enough mercury is liberated to keep the whole of the zinc amalgamated. Consequently local action is reduced to a minimum. In the larger cells mercury is placed at the bottom of the jar, and granulated zinc, lying in this mercury, is used for the positive plate. W. R. C.

1415. *Capacity of Accumulators.* **L. Jumau.** (Écl. Électr. 18. pp. 201–203, 1899.)—The author studied the variation of capacity with strength of acid. The experiments were carried out upon pasted plates. The capacity at first increases and then decreases as the strength of acid is increased, but the concentration which gives the maximum rises with the rate of discharge. The same is true of the positive and negative plates separately: the maximum points, however, do not occur at the same values of the concentration, the capacity of the negatives falling off rapidly with a strong acid. The greatest capacity would result by separating the plates and having strong acid round the positives, and dilute acid round the negatives. This being impossible in practice, the strength of acid should depend upon the rate of working, and the area of the negatives should be greater. W. R. C.

1416. *Accumulator Tests.* **M. Schoop.** (Ind. Élect. 8. pp. 29–31, 1899.)—The author emphasises the importance of studying the behaviour of the positive and negative electrodes separately by

means of a supplementary electrode, and describes a special form of the latter which gives accurate results. The electrode consists of a pool of mercury at the bottom of a porous pot, covered with a thin layer of mercuric sulphate; the cell is filled up with dilute sulphuric acid, or with a gelatinous electrolyte formed by adding silicate of potassium to the dilute acid. A platinum wire insulated by a glass tube makes contact with the mercury. The porous cell is placed in the electrolyte of the cell to be examined: the potential differences between the terminals of the cell, and between the supplementary electrode and each terminal, are measured on open and closed circuit at intervals during charge or discharge at various constant rates. From the results curves are plotted showing the variation of E.M.F. and resistance for each plate, the period of exhaustion of the individual plates during discharge, &c. The author gives the curves for a pair of Gottfried plates, and briefly discusses the inferences to be drawn from them. (See also 1899, Abstract No. 1068.) A. H. A.

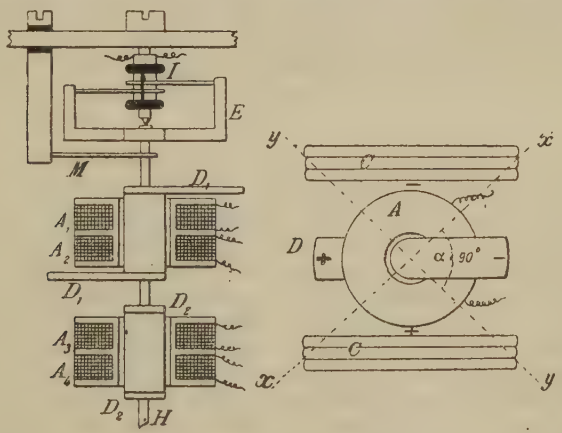
1417. *Accumulator Construction.* **D. E. Fitz-Gerald.** (Elect. Engin. 23. pp. 277–278, 463–464, 531–532, 564-565, 1899).—Continuation of articles on this subject. EDITOR.

1418. *Magnetic Cut-out.* **M. Schiemann.** (Zeitschr. Elektrotechn. 5. pp. 3–6, 1899.)—In this switch (which is very fully illustrated by drawings and photographs), after the circuit has been broken automatically by reason of a short-circuit, it is not possible to again complete the circuit through the main contact-arm of the switch until the short-circuit has been removed. This is effected by employing two contact-arms both actuated from one handle; viz., a main contact-arm, and an auxiliary contact-arm which engages with a fixed carbon contact-piece and serves to make and break contact, the main contact-arm following at a short distance behind. The armature of the controlling electromagnet is connected by linkwork with a finger which, if the short-circuit is not removed, and the auxiliary arm is brought into contact with its contact-piece, will stand in the path of a projection on the handle in such a position as to disconnect the main contact-arm from the handle before it engages with its contact-piece, the auxiliary arm also flying back. A suitable resistance is introduced into the circuit of the auxiliary arm. C. K. F.

1419. *Vulcain Energy Meter.* **M. Aliamet.** (Electricien, 17. pp. 193–198, 1899.)—This is a motor meter, and generally resembles the Thomson-Houston type. The details peculiar to

the instrument are described, the chief novelty being in the brake, which consists of a light copper cylinder acted on by a ring of magnets; the latter can be raised or lowered simultaneously by a screw, thus altering the damping and affording a ready means of adjusting the calibration. By various refinements the friction has been reduced so much that the constant loss in the shunt circuit is under 3 watts, while the motor starts with 0·14 per cent. of its normal full load. The article concludes with a brief account of the method of calibration, and a calculation showing the importance of a small loss in the shunt. A. H. A.

1420. *Peloux Energy Meter.* (Écl. Électr. 19. pp. 36–37, 1899.)—In the earlier form of this meter the main current is led through a simple armature, consisting of two coils set at right angles, one below the other, in a magnetic field produced by fine wire coils in shunt to the circuit. These coils are excited in proper order by means of a two- or four-part commutator, so as to maintain the rotation. In an improved form (see figure) there



are no moving coils; the armature consisting of two Z-shaped iron inductors, D_1 D_2, set at right angles, which are magnetised by stationary coils, A_1 &c., of fine wire in shunt, and rotate in a magnetic field produced by the main current flowing in coils, C. The spindle H carries brushes, E, which bear on a fixed commutator, I, and excite the shunt coils in the proper order. The lower end of the spindle carries a magnetic brake. The apparatus is very efficient and accurate. A. H. A.

1421. *Meters.* **H. Armagnat.** (Écl. Électr. 18. pp. 331–336, 407–412, 457–461, 494–498, 1899.)—Illustrated descriptions

of supply meters including those of Hummel, Aron, Ferranti, Cauderay, Beaumont, Browne, Emmot, Watson, Bastian, Evershed, Hookham, Feldmann, Steinmetz, Shand, and Thompson and Pratt. EDITOR.

1422. *Measure of Horse-Power.* (Engineer, 87. pp. 227–228, 1899.)—This paper contains in tabular form a number of numerical equivalents of 1 H.P. In one section the equivalents are given in terms of the working force and the distance worked in a certain time—*e.g.*, mile-tons, foot-pounds, kilogram-metres, per hour, per minute, and per second respectively. In hydraulics, the equivalents are expressed in terms of quantity of water and of pressure expressed in various ways. In the same way a number of thermal equivalents are expressed—*e.g.*, heat units, steam evaporated, or fuel burnt, per unit of time. A. S.

1423. *Cranes and Elevators.* **G. Richard.** (Écl. Électr. 19. pp. 15–23, 1899.)—Illustrated description of Sprague, Siemens and Halske and Roberts electric elevators; also of Sawyers electric traveller, and Thomson-Houston electric compressor. EDITOR.

1424. *Elevators in the Ivin's Building, New York.* (Eng. News, 41. pp. 273–275, 1899.)—This building has 26 floors, contains 950 offices accommodating 4,000 people, and passes through its doors 20,000 a day. There are 15 Sprague elevators of various sizes; 10 are passenger elevators arranged in a semi-circle and running from the ground floor to the 25th and 26th stories, a height of about 300 feet. Another lift, intended for safes and heavy freight, runs from the sub-basement to the 25th floor, a lift of 324 feet. Details are given of the roping-up, which is on the Sprague system with three fixed sheaves, and four travelling sheaves attached to a collar. This collar, or crosshead, is driven by a ball-bearing nut on a vertical screw about 23 feet long and 3 inches in diameter, which is driven by a vertical motor. The ratio of the travel of the nut and the travel of the car is 1 to 16. The car is counter-weighted by the cables, together with a small multiplying travelling counter-weight, provided with a chain to counter-balance the varying weight of cable suspended from the counter-weight. The ball-bearing nut, whose travel along the screw drives the collar to which the cables are attached, is only prevented from turning by its friction against the collar. This arrangement provides an easy safety device for over-winding, as it is only necessary to interfere with the travel of the nut when it will rotate with the screw instead of moving along it. The usual slack-cable, no-current, and other safety devices are pro-

vided. The method of controlling is by means of a Sprague pilot motor, worked by a small hand-switch in the car; this switch is connected by a cable containing six wires with the operating switchboard in the basement. Each car has one panel on the board. Two of the six wires are for the car lights, one for the car switch, one for "up," one for "down," and one for "stop." If the car switch is moved on to the "up" point, magnetic switches on the board are operated, throwing the line current into the main motor armature, through sufficient resistance to just hold the armature while the brakes of the main and pilot motor are released, and the armature of the latter begins to revolve and rotate a rheostat arm. This cuts out the main armature resistance and thus increases the speed and torque of the main motor. To stop the car, the operator simply leaves go of the switch handle, when the rheostat arm is automatically revolved back into the off position. The car descends entirely by gravity, the armature of the main motor first being short-circuited, and then resistance gradually cut into the armature circuit by the pilot motor, thus increasing the speed of the car. As it reaches the bottom, an independent retarding circuit is introduced while the resistance in the armature circuit is gradually reduced. The average hoisting current for the average live load in the car will not exceed 175 amperes at 120 volts, while the kilowatt hours per car mile will not exceed $3\frac{1}{2}$.

E. H. C.-H.

1425. *Motors in a Printing Office.* **C. A. Dresser.** (Elect. World, 33. pp. 233–234, 1899.)—With ordinary driving, the plates are put on to a Hoe press by two men, one using a foot pressure friction clutch and another signalling the exact points of stoppage. Rolls of paper (2,000 lb.) are placed at one end of the press, and two operators thread the sheet cautiously through its intricate path, which is about 60 feet in length; the jerky motion of the machine resulting from mechanical driving often breaks the paper and requires a repetition of the process. In the press room of the *Chicago Daily News* two motors are used, one a 5 H.P., 6-pole motor at 200 r.p.m. The speed of the press at the maximum speed of this 5 H.P. motor is 10 r.p.m. The speed regulator is moved by a compressed air cylinder with dash pot, controlled from four points on the press having 4-way compressed air-cocks. By manipulating an air-cock, the operator can move the cylinder on the press any distance down to $\frac{1}{16}$ inch. The main power for the press is derived from 40 H.P., slow-speed multipolar motor. The motor controller has 55 contact points, controlled from nine push-button stations, each also containing compressed air-valves. The paper from the main roll passes over two tension rollers, which are released when the paper is broken, and which shut down the press. In the basement below each press is a roll holding 8,000 lb. of paper. These rolls are driven

by motors which bring to position a new roll whenever one s used up. At $\frac{1}{20}$ full speed a new paper strip is pasted on to the end of the old, and in thirty seconds the press is again operating at full speed, namely, 24,000 sixteen-page papers per hour.

M. O'G.

1426. *Constants for Power Transmission.* (Eng. News, 41. p. 220, 1899.)—The constants used in the calculation of lines for alternate-current transmission are here tabulated for gauges of wire from 102 to 460 mils, for lengths of 1,000 feet and 1 mile respectively, under the headings: (1) Resistance at 75° F.; (2) Inductance in milhenrys; (3) Capacity in microfarads; (4) Current at 100 cycles and 10,000 volts to neutral, *i.e.*, in a 20,000-volt single-phase and a 17,300-volt three-phase line; and (5) Reactance at 25, 40, 60, and 125 cycles respectively. R. A.

1427. *Electric Siren.* **D. H. Keeley.** (Canad. Elect. News, 9. pp. 37–38, 1899.—This is a description of an electric fog-horn invented by A. G. Trudeau of Ottawa. It consists of two huge funnels made of $\frac{1}{4}$ inch copper. Each of the funnels projects 6 feet 6 inches from the stand at right angles to each other. In each of these funnels or horns a vibrator or sound producer is placed, the object being to use them alternately or simultaneously as may be desired. The diaphragm is said to be of a specially prepared material and of magnetisable character, a suggested modification being one of bell metal or other non-magnetic material provided with small projections of iron to serve as armatures for the actuating electromagnets, and it is secured in the frame by an annular clamp, somewhat after the fashion of a drumhead. A screw device by which the amplitude of the vibrations of this diaphragm is to a certain extent regulated, is mounted opposite the centre in a crosspiece at the back. A group of electromagnets, made up of laminated iron cores wound in the ordinary way, is fixed in the frame. The stand is surmounted by a large hollow cast iron sphere, from which the horns project. This sphere is divided into two, the back portion opening on a strong hinge. The vibrator is self-contained, and may be taken out and replaced by another in a moment. The instrument is operated by means of alternating currents. W. G. R.

1428. *Flow of Steam through Pipes.* **R. C. Carpenter** and **E. C. Sickles.** (Mech. Eng. 3. pp. 389–390 and 413–415, 1899. Paper read before the American Society of Mechanical Engineers, December, 1898.)—The experiments described were made to determine the coefficient of friction of steam flowing at

different speeds through pipes and fittings. The measurements of condensation and flow were made on a 90-feet length of piping 2 inches diameter, leading from the Sibley College boiler rooms. Accurate and carefully calibrated steam gauges, subdivided to read fractions of a pound, were used to determine the pressures. Steam separators and throttling calorimeters were used to determine the quality of the steam.

If E be the total loss of energy, E_c the dynamic condensation energy, and E the loss by friction, $E - E_c = E_f$. Many expressions for the value of E_f are given by various writers; the authors reduce all their experimental results to Unwin's formula—

$$E_f = f \frac{V^2}{g} \frac{2}{d} WL.$$

The value of f depends on the velocity, and, for velocities of 100 feet per second, is expressed by Unwin's formula—

$$f = K\left(1 + \frac{3}{10d}\right)$$

in which K is the coefficient to be found by experiment. If p be the loss of pressure in pounds per square inch, D the weight of the fluid per cubic foot, and w the flow in pounds of steam per minute—

$$p = \frac{1}{20{\cdot}66} K\left(1 + \frac{3{\cdot}6}{d}\right) \frac{w^2 L}{D d^5}$$

For a 2-inch pipe this reduces to $p = 1447 \frac{w^2 K}{D}$.

In the first set of experiments, in which the steam was discharged through a $\frac{3}{4}$-inch nozzle, the highest value of K was ·00276, the lowest ·00180, the average ·0021. Neglecting the lowest value, which was considerably less than the others, the average value of K was ·00234. In the second set of experiments, in which the steam was discharged through a $\frac{1}{8}$-inch nozzle, the average value of K was ·00298. The friction in elbows and valves was measured by the same apparatus, and taking the formula—

$$H_e = f_e \frac{V^2}{2g}$$

where H_e is the loss of head in feet for elbows, f_e for 90° elbows was found to be 5·6, for globe valves 8·2, and for gate valves ·005.

A table is calculated giving the delivery in pounds per minute by pipes of various diameters and lengths, for an absolute pressure of 100 lb. and a drop in pressure of 1 lb. A diagram of reduction factors for different steam pressures and different drops in pressures is given, so that it is easy by using the tables and the curves to determine the flow of steam through a pipe under any set of conditions. A. S.

GENERATORS, MOTORS, AND TRANSFORMERS.

1429. *Induction Generators.* **Leblanc.** (Écl. Électr. 18. pp. 488–491, 1899.)—The article contains an elaborate mathematical theory of the special form of exciter for induction generators described in Abstract No. 908 (1899). A. H.

1430. *Analysis of Dynamo Losses.* **G. Dettmar.** (Elektrotechn. Ztschr. 20. pp. 203–205 and 218–220, 1899.)—The following method, which for a number of years has been used by the author, allows of a complete analysis of the various losses taking place in a dynamo. The machine under test is run as a separately excited motor, the exciting current and P.D. across the brushes being varied while the speed is maintained constant. The values of the P.D. and the armature current are noted. Several such sets of readings are taken, each set corresponding to a definite speed. From the readings curves are plotted on squared paper, the E.M.F. being represented by abscissæ and the corresponding watts absorbed by the armature by ordinates. By producing each curve backwards until it intersects the axis of watts we obtain the watts absorbed by friction at the speed corresponding to the curve. If the exact shape of the curve close to the axis of watts should appear doubtful, the value of the intercept F on that axis may be obtained from the fact that each curve may be represented by an equation of the form $w = F + aE^2$, where w denotes the watts, E the E.M.F., and F and a are constants for each curve. Having found the values of F for the various curves, we plot a new curve, with speeds as abscissæ and values of F as ordinates. From this curve the watts absorbed by friction at any given speed may be at once read off. Numerous experiments on a number of different machines have shown that this curve is never a straight line, but that it is concave upwards, showing that the resisting torque due to friction increases with the speed. The machine is next run under normal excitation, readings of the speed, P.D. across brushes and armature current being taken as before. From these a curve (α) is plotted, with values of the E.M.F. as abscissæ and those of the armature current as ordinates. From each ordinate of this curve is subtracted an amount representing the current required to overcome frictional resistances at the corresponding speed; this current is equal to the quotient of the watts absorbed by friction at that speed (obtained from the F-speed curve) by the E.M.F. The ordinates of the new curve (β) so obtained represent the currents required to overcome the hysteresis and eddy-current torques. The intercept on the axis of current gives the current required to balance the hysteresis torque. By drawing a straight line (γ) parallel to the axis of E.M.F. through the point of intersection of

(β) with the axis of current, we determine the currents required to balance the eddy-current torque; these currents being represented by the vertical intercepts between (β) and (γ). Finally, by drawing an additional set of curves (α^1), (β^1) and (γ^1), obtained by multiplying the ordinates of (α), (β) and (γ) respectively by the corresponding values of the E.M.F., we are enabled to determine at a glance the distribution of losses for any given E.M.F. corresponding to the particular excitation used: the ordinates of the straight line (γ^1) giving the watts lost by hysteresis; the intercepts between (γ^1) and (β^1) those lost by eddy-currents; and the intercepts between (β^1) and (α^1) the watts lost by friction. The following results were obtained by means of this method in the case of a belt-driven 6 pole generator running at 550 r.p.m., having an armature resistance (brush contacts included) of ·005 ohm and developing 550 amperes at 110 volts: hysteresis loss, 670 watts; eddy-current loss, 1826 watts; friction, 1400 watts. A. H.

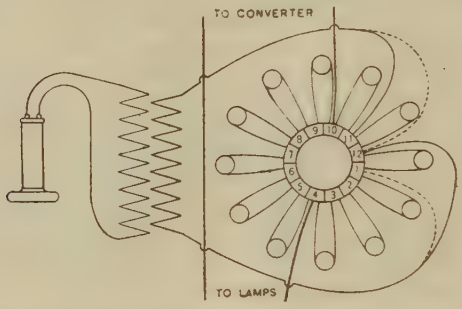
1431. *Dynamo Testing.* **C. Liebenow.** (Elektrotechn. Ztschr. 20 pp. 274–275, 1899.)—The author describes a method practically identical with that used by Routin (see 1898, Abstract No. 199), and gives the following results obtained with it in the case of a 150-kilowatt generator developing 2,300 amperes at 65 volts and 254 r.p.m., and having an armature resistance of ·001665 ohm.

Bearing friction	·41	kilowatt
Brush „	·69	„
Hysteresis loss	·43	„
Eddy-current loss	2·00	„
Loss by heating of armature	8·80	„
„ „ „ field coils	2·27	„
Total loss	14·6	kilowatts

The efficiency is therefore 91·1 per cent. A. H.

1432. *Armature Testing.* **W. H. Hall.** (Elect. World and Elect. Engin. 33. pp. 407–408, 1899.)—The accompanying figure illustrates the method of test. Open one side of a lamp circuit carrying from 5 to 20 amperes alternating current, and clamp the two ends of the break to opposite segments of the commutator, using a clamp that will not make a short circuit. If coils and commutator are perfect, this will divide the current into two equal parts. Prepare an induction coil with primary of very low resistance, and connect the secondary with a good telephone receiver. Proceed to test the coils of the upper half of the

armature with two ends of the primary, keeping the receiver to the ear. In the figure, the coil connecting segments 1 and 12 is broken, and therefore no sound is heard until the wires from the primary span these segments, when the sound will be very loud, locating at once an open circuit in the coil, which may be



marked. Temporarily short-circuit these two segments, and proceed to test other coils.

When an alternating current is not available, a number of primary cells in multiple may be used, with a good interrupter in the circuit. W. G. R.

1433. *Dynamos.* **C. F. Guilbert.** (Écl. Electr. 18. pp. 417–421, 1899.)—An illustrated description of recent patents. EDITOR.

1434. *Fan Motors.* (Amer. Electn. 11. pp. 155–163, 1899.)—An illustrated description of a variety of fan motors. EDITOR.

1435. *Rotary Converters.* **R. B. Ritter.** (Écl. Électr. 18. pp. 20–30, and 48–55, 1899.)—These are two articles on the manufacture and running of rotary converters. The descriptive part is confined to Alioth converters installed at various stations. W. G. R.

POWER DISTRIBUTION, TRACTION, AND LIGHTING.

1436. *Storage in Traction Power Stations.* **R. McA. Lloyd.** (Amer. Instit. Elect. Engin. Trans. 16. pp. 59–74, 1899. Discussion, pp. 75–103.)—In very many American stations the average load is far less than the maximum load, and the latter is far below the capacity of the generating plant, so that the efficiency of the plant is very low. The author urges the value of storage for rectifying this fault, and considers three sizes of battery : "small," to level the momentary fluctuations ; "medium," to level the hour-to-hour variations ; and "large," to level the load curve over the whole day and night. In the first case, capacity is unimportant, but high rate of discharge is essential ; the battery will cost less than generating plant for the same duty, and will be able to run a few cars and lamps at night when the engines are stopped. In the second case the battery will cost twice as much as a "small" battery, but will still cost less than the generating plant displaced, and will increase the efficiency of working to a marked extent. Lastly, a "large" battery will cost twice as much as a "medium" one, will cost as much as the generating plant displaced, and will be able to carry the whole load for some hours. The efficiency will be still higher, as the machinery will run at constant load, and the labour charges will be less. The following table shows the relative results for a stated case :—

	Outlay with	Cost of generating plant.	Cost of Storage Battery.	Total cost of station plant.	Cost of Coal per day.	Cost of Coal per annum.	Sav'g in Coal.	Saving in coal and saving in int. 5 p.c.
1	No Battery	$115,000	$	$115,000	$30	$10,950	$	$
2	Small Battery	60,000	20,000	80,000	25	9,125	1,825	3,575
3	Medium ,,	50,000	35,000	85,000	20	7,300	3,650	5,150
4	Large ,,	40,000	70,000	110,000	15	5,475	5,475	5,525

	Cost of Real Estate and Buildings.	Repairs and Depreciation.	Saving in Labour per annum.	Saving in water, oil, waste, &c.	Total Saving.	Estimated Addition to receipts.	Net Advantage in operation.
1	All the same	All the same		$	$	$	$
2				100	3,675		3,675
3				200	5,350	1,000	6,350
4			$1,200	300	7,025	5,000	12,025

The author allows 10 per cent. per annum for repairs and depreciation on the entire station plant, including the battery. He suggests that all electric supply should be carried out with rotary converters and storage batteries from large stations working at constant load and distributing at high pressure, and believes that the most profitable proportions of plant investment are 30 per cent. generating machinery and 70 per cent. storage battery. The paper is illustrated with a number of load curves showing the effect of storage in actual cases.

In the discussion, **G. Hill** strongly supported the author's views, and described an instance of electrical supply where a large saving was effected by the use of complete storage. He pointed out cases where, on the other hand, storage would not be advantageous. **C. O. Mailloux** and **E. T. Birdsall** agreed with the author, and **J. M. Smith** described a test bearing out his facts. **H. B. Coho** considered 10 per cent. depreciation too high for machinery and low for batteries. In reply, the author pointed out that when the battery plates are renewed the best types are used, so that the battery is always nearly up to date; whereas machinery becomes obsolete.

In the discussion at Chicago, **A. Dow** supported the author, but considered that an engine with a heavy flywheel was ample provision for the momentary fluctuations, and that "small" batteries were most useful as regulators at the end of feeders. **J. Appleton** stated that 6 per cent. was fair for the actual depreciation of cells, but **M. Coster** preferred 10 per cent. **B. J. Arnold** said the cost per kilowatt-hour of storage batteries varied from £8 for low discharge rates to £35 for high rates. **J. Appleton** described an instance of a "small" battery at a feeding-point nine miles from the power station: the maximum load was 1,000 amperes, but the current supplied through the feeder was 400 amperes continuously. The energy efficiency of the battery under these conditions of intermittent charge and discharge, as measured, was 90 to 95 per cent. Other instances were described showing the saving in copper and machinery. The reason of the high efficiency was the short duration of the charge and discharge periods: the number of cells must be carefully adjusted to obtain the best effects.

A. H. A.

1437. *Increasing the Utilisation of Central Station Plant.* **A. Meynier.** (Ind. Élect. 8. pp. 78–81, 1899.)—The author describes an instance where a saw-mill was driven by turbines, the speed of which varied from 15 to 75 r.p.m., on account of the extreme variations of load. To remedy this, a dynamo was coupled to the turbines and joined to the supply mains; during heavy loads the machine receives power from the mains, and assists the turbines, while during light loads the dynamo absorbs the surplus power of the turbines and delivers it to the mains,

the speed remaining nearly constant. During the day the former action predominates, and during the time of heavy load on the mains the latter occurs, the duration of each being regulated by the meter readings so as to make the amount of energy supplied equal to that restored. Similar arrangements are outlined, by means of which it is urged that the output of the station could be maintained practically constant at all times.

A. H. A.

1438. *Electric Traction.* **C. P. Feldmann.** (Elektrotechn. Ztschr. 20. pp. 144–147, 1899.)—This is a paper read before the Elektrotechnische Gesellschaft at Köln, in which the various systems of electric propulsion on ordinary railroads are discussed.

C. K. F.

1439. *Electric Tramways.* **G. Conaty.** (Railway World, 8. pp. 110–114, 1899. Paper read before the Birmingham Association of Mechanical Engineers, February, 3, 1899.)—The author discusses generally the equipment of electric tramways. With regard to permanent way he is in favour of pitch pine longitudinal sleepers bedded in concrete. The sleepers to be 9 in. $\times 4\frac{1}{2}$ in. This gives the necessary elasticity, and will diminish the repairs necessary to both permanent way and rolling stock. W. R. C.

1440. *Cost of Speed in Rapid Transit.* **J. R. Cravath.** (Elect. World and Elect. Engin. 33. pp. 400–402 and 437–439, 1899.)—The speed curves for a transit service consist of three parts : First, acceleration up to a certain maximum speed. Second, a period of time, however short, between the time maximum speed is attained and the time brakes are applied, and during which time the motors may be either coasting with current off or running with current on to overcome the train friction only. Third, retardation or braking, during which time the energy stored up in the train is wasted in the brake to bring the train to rest.

It is evident that if it is required to run, say, 2,000 feet in a given time, the greater the acceleration the less will be the maximum speed necessary to run the distance in that time and the less the energy that must be wasted in the brakes at the end of the run. The acceleration should also be rapid and the maximum speed low, because with an electric motor the current required to produce a given acceleration varies directly as the speed for which the motor is wound or geared. With a rapid acceleration it is better to make the maximum speed fairly high and then switch off the current and allow the train to drop below its average speed before applying the brakes.

As the weight of train on the drivers has an important bearing

on all rapid transit schedules, three cases of electrical equipment are considered: First, four-car elevated trains with a motor car at the head of the train. Second, four-car elevated trains with half the axles on the train motor driven as in the multiple unit system. Third, four-car elevated trains with all the axles motor driven on the multiple unit system.

The maximum horizontal effort that a motor car can exert on a dry track is usually accepted to be one-fourth the weight on the drivers, or 500 pounds per ton on the drivers.

To allow for slippery track the author assumes that the maximum horizontal effort is 350 pounds per ton on the drivers.

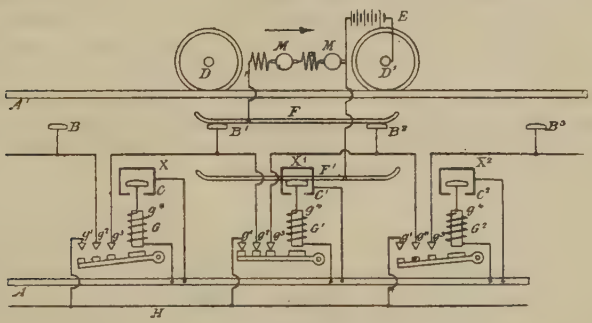
One of the first things to be noticed about the calculations on energy consumption per run is the large amount of energy taken to keep the train in motion after it is up to speed where there is a considerable run at maximum speed. This is most noticeable in the case of the multiple unit train with four motors per car and is the least with the single motor car train. The reason for this is that in the multiple unit trains the motor capacity is larger in proportion to the weight of the train than with the single motor car because of the more rapid accelerations that must be provided for. The importance of using the coasting method as much as possible is greater with the multiple unit system than with the single motor car. The maximum economy of the motor car system is less than the multiple unit, but if the multiple unit system is not rightly used it may show an economy much lower than the lowest with the motor car under conditions that may occur in practice. The possibilities both in great economy and greatest lack of economy are with the multiple unit. As regards cost of maintenance the motor car has the advantage. W. G. R.

1441. *Rail Bonding.* **C. Thonet.** (Électricien, 17. pp. 150–152 and 171–173, 1899.)—This paper is a report presented to the tenth annual meeting at Geneva of the *Union Internationale Permanente de Tramways.* Mention is made of the methods of bonding used by a number of Continental tramway companies, and the conditions which should be realised are discussed. The following conclusions are arrived at: 1. The negative of the dynamo should be connected to the rails. 2. The cross section of the bonding should be ample. The rails should be cross-connected every 50 metres; and, in the case of double lines, the two lines should be connected. 3. Return feeders of suitable cross section should be connected to certain points of the network. 4. Where corrosion is detected the potential should be equalised. W. R. C.

1442. *Surface-Contact System of the Union Elektricitätsgesellschaft.* **M. Kubierschky.** (Elektrotechn. Ztschr. 20. pp.

295–301, 1899.)—A full description is given of this system, the connections of which are shown in the figure below.

The only moving part of the relay switch is a heavy iron plunger which is a loose fit in a metal tube and is pulled up with a force of 5 kilograms by 12 amperes round the spool, thereby closing three carbon contacts carried on triangular projections at the bottom of the plunger. Sparking at the surface knobs is provided against. A four-cell battery makes the first contact and is afterwards kept charged by part of the motor current. The studs are in two rows, a "high-tension" row connected through the switch to the line, and a "low-tension" row connected to earth



through the relay magnet. The low-tension studs are surrounded by an earthed ring through which any leakage current will flow direct to earth without magnetising the relay. Another point claimed is that the relay spools are in series with the motors and on their earthed side. The switches are independent and can be grouped in substations. E. H. C.-H.

1443. *Murphy Third-Rail System.* **E. V. Baillard.** (Eng. News, 41. p. 303, 1899.)—This system requires 180 switches per mile of single track, and these switches constitute one-third of the total cost of outside construction. Depreciation on the switches may be written at 10 per cent. and on the track 1 per cent., giving a total of $4\frac{1}{3}$ per cent. for the whole outside construction, as against 15 per cent. allowed by conservative engineers for overhead trolley construction. Figures are given of the leakage from 15-feet live sections covered with water, mud, and salt, showing under worst conditions 12 amperes leakage: no particulars are given as to the amount of street refuse present in the mud. The present switches hold up with 12 amperes, whilst the minimum current required to operate the car varies from 16 to 20 amperes, and it is therefore intended to set the switches for a minimum current of higher value. (See also 1899, Abstract No. 523.) E. H. C.-H.

1444. *Automatic Block System.* **C. F. Bancroft.** (Eng. News, 41. pp. 330–331, 1899.)—Illustrations are given of an automatic-block system for high-speed electric cars, which has been in successful operation for the past six months on a branch of the Lowell and Suburban Railway in Massachusetts, and which is now installed on the main line of that railway. It is designed for single-track roads using turn-outs, and is so arranged that each car as it advances operates switches controlling the turn-out which it is on, and the one next in advance. The apparatus consists of contact-plates placed at the turn-out approaches and exits, with automatic magnetic switches which are so interconnected that when a car leaves a turn-out it cuts the current off from the turn-out next in advance on the side which a car would take coming towards the occupied turn-out, and it also cuts the current off from the side of the turn-out which it is leaving. The car upon reaching the next turn-out replaces the switch. [A similar automatic-block system for electric railways was designed by Ayrton and Perry and described by them at the Royal Institution about fifteen years ago]. R. A.

1445. *Meter Rates.* **E. L. Debell.** (Electricity, N.Y. 16. pp. 101–102, 1899.)—Running expenses are a small portion of the total in electricity supply. Aberdeen electricity station in 1897 could supply $3\frac{1}{4}$ million units, but only yielded 214,000. The best consumer employed 2 H.P. of the station's capacity (less than £80 of its capital, *i.e.*, £5 10s. of the annual capital charges), employed the service for 2,000 hours, and produced a revenue of £57 10s., namely £52 over the capital charges. The worst consumer employed 177-H.P. (£7,400 of the station's capital, *i.e.*, £5,100 of the annual capital charges), used the service for only 61 hours, and paid only £164, namely, less than one-third of its proportion of the capital charges. To overcome this injustice various devices are recommended : 1. Wright's Demand Indicator. 2. The General Electric 2-rate meter. 3. The Oxley multiple rate meter switch. 4. A fixed rate per lamp wired plus a smaller charge for current. M. O'G.

1446. *Meter Rates.* **K. Wilkens.** (Elektrotechn. Ztschr. 20. pp. 262–263, 1899.)—The author deduces the two following equations for the prime cost of a kilowatt-hour for lighting (S_L) and for power (S_K) :

$$S_L = \frac{B}{L+K} + \frac{Z}{L + \frac{K \cdot d_L}{d_K}}$$

$$S_K = \frac{B}{L+K} + \frac{Z}{K + \frac{L \cdot d_K}{d_L}}$$

where B = the total expenses dependent on the amount of energy delivered; Z = the total fixed expenses; L = the total useful energy delivered for lighting; and K = the total useful energy delivered for power (thus $Z+B=S_L.L+S_K.K$); d_K = the time during which each kilowatt is used for power, and d_L = the time during which each kilowatt is used for lighting. The following example is given: A central station having a capacity of 600 H.P. delivered 100,000 kw.-hours for light (L), and 500,000 kw.-hours for power (K). Since the corresponding [? average] values were 500 kw. for light and 435 kw. for power, $d_L = 100{,}000/500 = 200$ hours, and $d_K = 500{,}000/435 = 1{,}150$ hours. B = 67,000 marks and Z = 80,000 marks. On inserting these values in the above equations, we have $S_L = 53{\cdot}96$ and $S_K = 18{\cdot}61$ pfennigs per kilowatt-hour. C. K. F.

1447. *Differential Arc Lamp.* **C. Vigreux** and **L. Brillié.** (Ind. Élect. 8. pp. 59–62, 1899.)—The object of the inventors was to dispense with the ohmic resistance usually required to enable single arc lamps to burn steadily. This they claim to have accomplished. The arc is controlled by series and shunt coils acting differentially on a brake which oscillates on knife-edges, and a flywheel driven by gearing from pulleys to which are attached the cords which support the carbon-rods. The description of the lamp cannot be abstracted. It is stated that these lamps can be used singly on 45-volt circuits, two in series with 85 volts, three in series with 110 to 135 volts, and so on. Some calculations are given, and an actual installation described, to show the gain in efficiency due to the use of these lamps. A. H. A.

1448. *Working Arc Lamps Three in Series.* **W. Wedding.** (Elektrotechn. Ztschr. 20. pp. 263–265, 1899.)—In this paper the author describes experiments made with Messrs. Körting and Mathiesen's system of running three differential arc lamps in series with each other and with a starting resistance, which is gradually cut out after turning on the current, across 100-volt mains. The electrical and photometric measurements made are given in tables and curves, the most important results being as follows: With a pressure across the mains of 110 volts and a current of 7·6 amperes, each lamp absorbed 279 watts and gave a light = 587 C.P.; with a current of 7·9 amperes, each lamp absorbed 289 watts and gave a light = 572 C.P., the mean result being 2050 C.P. for 1 kilowatt. C. K. F.

1449. *Arc Lamps.* **G. Richard.** (Écl. Électr. 18. pp. 174–182, 1899.)—A description of various lamps. EDITOR.

TELEGRAPHY AND TELEPHONY.

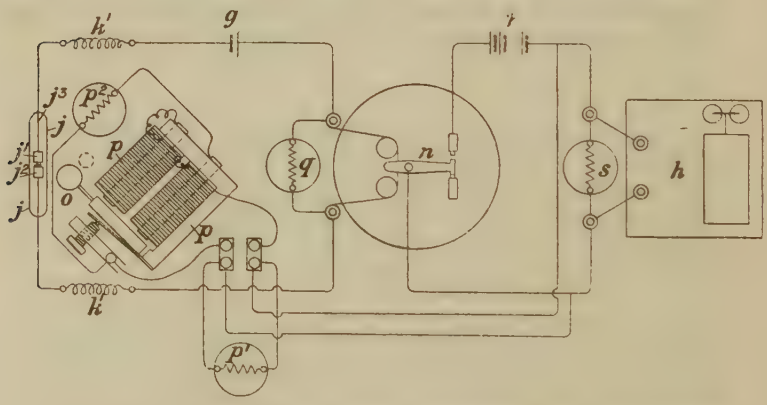
1450. *Induction Telegraphy.* **J. Voisenat.** (Écl. Électr. 19. pp. 23–27, 1899.)—General discussion, and consideration of Lodge's, Evershed's, and Preece's papers. (See 1899, Abstracts Nos. 960, 961, 962.) M. O'G.

1451. *Tall Wires in Wireless Telegraphy.* **R. Kennedy.** (Elect. Rev. 44. pp. 583–584. 1899.)—Starting from the ordinary formula for E.M.F. induced by a changing magnetic flux F in a coil of r turns at a frequency n—

$$e = 4{\cdot}45 \text{ F } rn \text{ } 10^{-8}.$$

The author suggests that the tall wires correspond to coils having half a turn. F is small, but n, the frequency, is supposed high enough to give E a value whose fluctuations are noticeable with a coherer. M. O'G.

1452. *Wireless Telegraphy.* **G. Marconi.** (Instit. Elect. Engin. Journ. 28. pp. 273–290, 1899. Discussion, pp. 291–297.)—Transmission is effected by a long or short closing of the primary of a 10-in. coil connected to small spark knobs in air. No



care is taken to polish these knobs. The receiver connections in the fig. show at p^2,q,s, the non-inductive shunt resistances across all spark terminals. The resistance of the coherer falls to between 500 and 100 ohms. The inertia of the Morse instrument causes the *dash* to be printed as a dash, in spite of the rapid intermission at the relay. No results would be obtained across a hill without a tall wire capacity. A horizontal wire of 300 ft. added to a wire

30 ft. high tended to the disadvantage of signalling. Signals were transmitted over the following distances :—

Between the Isle of Wight and a steamer, mast 60 ft. high, distance 18 miles.
,, Ballycastle and Rathlin, masts 100 ft. and 80 ft., distance 25 miles.
,, Kingstown and a steamer, masts 110 ft. and 80 ft., 25 miles.
,, Osborne House and a steam yacht, masts 100 ft. and 83 ft., 7 miles through a hill.
,, South Foreland Lighthouse and East Goodwin, mast 80 ft. high, 12 miles.

Many wire stays about the lower 60 ft. of the masts had no noticeable effect, but the lighthouse on Rathlin was thought to diminish the clearness.

J. A. Fleming sketched an experimental coherer and confirmed the negative effect of horizontal wires. **E. Murray** considers a tall wire effect to be similar to an increase of tension at a point in a conductor. **W. P. Brett** has suddenly broken the earth connection while signalling over 12 miles and found no alteration in definiteness. **Capt. Kennedy** had used balloons and kites for the vertical wire. **J. Gavey** quoted examples of the law that the speaking distance varies as the product of the heights of the wires. With vertical wires syntony does not come into effect. Higher conductors are required over land than over sea, a result confirmed by Slaby. The height now required to speak over one mile of sea is 20 ft. A good earth contact was unnecessary, and a small capacity could be substituted for metallic continuity at the receiving end, but not at the transmitting end. Good results depended more on high frequency than on the amount of energy, thus five amperes with a 6-in. spark was better than 10 amperes with a 20-in. spark with the same coil and with contact-breaker so screwed up that the frequency was less. Up to half a mile reflectors were most useful, but beyond that they were disappointing. To screen the receiving apparatus from the violent effect of the transmitter in the same station Jackson and Marconi had adopted different ways. Protection from lightning deserved consideration. **M. O'Gorman** had made some experiments with coherers and small voltages, and suggested that as alternating currents are transmitted along the earth's surface if the frequency is high, the reversals of potential due to these currents would tend to charge the tall wire through the coherer. This explains earth conduction, the use of tall vertical wires, and allows for an earth connection consisting merely of a capacity. **L. B. Miller** had found several spark-gaps an advantage. A receiver wing need not make electrical contact with the coherer to be effective. **A. C. Swinton** had found that the resistance of a carbon coherer was affected by Hertz waves, and **A. C. Brown** stated that the change was gradual. **C. A. Stephenson** preferred inductive methods with a coil of cable for lightships, pointing out that Blake's conduction method had answered at Sandy Hook and his own experiences with electro-

magnets were satisfactory. The damping action of the earth on induction from horizontal coils is small. **S. P. Thompson** explained the advantage vertical wires derived from the reflective action of the conducting earth. If the vibrations are polarised a transparent reflector parallel to their plane would more readily reflect them, but the case is different with a metallic or conducting reflector. The greater absorption of rays travelling over land compared with water may be due to the greater conductivity of land. The mirror must be much larger than the oscillator and at a distance greater than a quarter wave from it: this implies a mirror five times the height of the vertical wire; and as the wave-length is about double the length of the wire, it implies an enormous mirror. **G. Marconi**: The oil spark-gap was abandoned because too variable. A little mercury is used in the coherers, and they are exhausted to about 1 millimeter. Coherers containing air diminish in sensitiveness. Earth connection at both stations is necessary for maximum distances, but even the vertical wire may be disconnected if its extremity is near the coherer, say 1 foot. The law of heights is discussed in the Ellettricista, August, 1897; in the Rivista di Artiglieria e Genio, 1897–98; and in a lecture by Bongiovanni at Ferrara, November, 1897. Screening from the transmitter is effected by enclosing all but the inker or recorder in an iron case, and interposing choking coils between the recorder connections. Fifty dry cells are now used at Osborne House; 100 dry cells at Alum Bay. If the conductor wires are slanting, they should be parallel for the best results. The conductor was sometimes suspended from the top of a cliff and earthed at the top end, instead of the bottom; thus at Alum Bay the wire hung 30 ft. out from the cliff and spoke to Bournemouth, 14 miles away. M. O'G.

1453. *Van Rysselberghe's Anti-Inductive Combination of Telegraphs and Telephones on Short Lines.* **M. Colard.** (Bull. Ass. Ing. El. Liège, 9. pp. 477–496, 1898.)—The analytical results shown in Bull. Ass. Ing. Elect. Instit., Montefiore, 1896–97, tome viii., series 2, p. 332, &c., are adopted, and the author concludes from a mathematical investigation (given in full) that the sinusoidal current in the line has maxima and minima intensities approaching 10 per cent. of the normal line current. He points out incidentally that electrostatic induction tends, in the conditions assumed, to produce in neighbouring telephone lines sounds which are approximately one-fifth lower in tone than those due to electromagnetic induction. The investigation practically results in a proof that in this anti-inductive system the currents and potentials are by no means of a simply damped form (as in a circuit containing only resistance and self-induction). The order of magnitude of the two chief oscillatory currents is calculated. M. O'G.

1454. *Intensity of Received Current in Van Rysselberghe's System.* **M. Colard.** (Bull. Ass. Ing. El. Liège, 9. pp. 497–515, 1898.)—The author assumes complex symbols for E.M.F's., current, and impedances, and thereby makes it legitimate to apply Ohm's and Kirchoff's laws to sinusoid currents as if they were direct. The calculations are done in full, and it is deduced that the line currents are at every instant equal and opposite. Hence, whatever current goes to earth by the condenser of one of the telegraphic stations comes back from the earth into the system by the other condenser, and the earth connection plays no part whatever. A further important conclusion is that for low frequencies the intensity of received current for the same impressed E.M.F. with Van Rysselberghe's system is greater than if the telegraphic instruments and their anti-inductive accessories were to be suppressed, provided always the capacities be retained. A numerical application is given, and the intensity of received current and lag are tabulated for various frequencies. Van Rysselberghe's system greatly increases the telephonic received current for women's voices. It is inferior for men's voices.

M. O'G.

1455. *Paper Telephone Cables.* **O'Gorman** and **Cozens-Hardy.** (Elect. Rev. 44. pp. 590 and 854, 1899.)—The specific capacity of paper used in telephone cables is 1·8. It is not possible to enclose 600 wires, 20 gauge, in a tube $2\frac{3}{4}$ inch diameter, and obtain a capacity of 0·08 mfd. per mile. Low insulation results from allowing the paper to be damp, but as the specific capacity of water is about 80 (for air = 1) for currents of telephone frequency, this had to be abandoned: 200,000 megohms per mile has also been obtained on long lengths without expense, but it is undesirable. The practice of making solid the ends of a cable with lead is criticised as well as the S type of paper insulation. [See 1899, Abstract No. 1255.] W. R. C.

1456. *Telephone Exchange in Paris.* **G. de la Touanne.** (Journ. Télégraph, 22. pp. 121–126, 146–155, 193–200, 223–228, 1898.)—Drawings and diagrams and full-length explanations are given of a 9,000 subscribers' multiple exchange, designed and ordered in 1895 by the French Government. M. O'G.

1457. *Recent Exchange Improvements.* **K. B. Miller.** (Elect. World and Elect. Engin. 33. pp. 469–471 and 502–503, 1899.)—An invention (by Thompson) is described which so arranges the cord circuits that an exchange equipped on the magneto-generator system may be worked during transformation

into the new style, viz., central battery and automatic call (cp. Elect. World, December 24, 1898) without disusing either the new or the old parts of the exchange. A further invention (of Wales) to improve existing methods of connecting local lines in a common battery exchange with long distance or toll lines is described. The object is to avoid false signals, due to the calling subscriber hanging up his receiver, or the waiting subscriber's line not testing busy during the interval between the call and his connection. M. O'G.

1458. *Telephone Exchanges.* **H. P. Clausen.** (West Electn. 24. pp. 127–128, 1899.)—Diagrams and details are given of power-driven generators for signalling, both when the generator is kept in constant motion and when it is only put in action when required for a signal. M. O'G.

1459. *Telephone Party Lines.* **H. S. Webb.** (Amer. Electn. 11. pp. 81–84, 1899.)—Describes method for preventing a subscriber from listening on his receiver to a conversation going on between two others when his local bell has not rung. Connections for six subscribers with locking and unlocking devices are illustrated, also connections for eight subscribers without the locking devices. M. O'G.

SCIENCE ABSTRACTS.

PHYSICS AND ELECTRICAL ENGINEERING.

OCTOBER 1899.

GENERAL PHYSICS.

1460. *Elasticity of a Pendulum.* **E. Almansi.** (N. Cimento, 9. pp. 260–278, 1899.)—The author deals mathematically with the influence of elastic deformations upon the motion of a reversible pendulum. To simplify matters, he assumes the hollow cylindrical portion between the knife edges to be the only part subject to elastic deformation, and calculates the bending moment for any cross-section and for any angle of deflection.

E. E. F.

1461. *Pumps.* **F. Neesen.** (Verh. Deutsch. Phys. Gesell. 1. pp. 90–94, 1899.)—Description of improvements in mercury air-pumps, and comparative investigations into the speeds of working of different kinds of air-pumps. A. D.

1462. *Flow Structures.* **K. Mack.** (Wied. Annalen, 68. 2. pp. 183–195, 1899.)—The author studied the vortex structures produced by allowing a solution of fuchsin to flow into water from below, the head and time of flow being accurately known. He studied particularly the effects of gravitation upon the shape assumed by the flow structures. For this purpose he varied the density of the solution by altering its concentration. The usual type of structure was the well-known upright mushroom, consisting of a stem of length varying with the pressure, and an upper flat part edged by a vortex ring. On stopping the flow the mushroom would become broader and flatter, eventually forming a pretty uniform horizontal layer of coloured liquid. When, however, the solution was dense, the vortex ring would drop down, and the liquid that followed would produce a kind of horn projecting above its surface. The author also studied the manner in which a new mushroom would deform an already existing horizontal layer. He found that it would lift it up as if it were

a heavy cloth, and the liquid would run down the sides of the mushroom as if the latter were solid. It would then get caught in the vortex and take part in its rotation. Non-circular apertures always produced circular mushrooms. E. E. F.

1463. *Absolute Measurement of Time.* G. Lippmann. (Comptes Rendus, 128. pp. 1137–1142, 1899.)—From the two expressions for an attactive force, $F=k^2\frac{Mm}{r^2}$ (M and m being masses, separated by the distance r), and $F=m\frac{d^2x}{dt^2}$, the author derives an equation for the Newtonian constant, $k^2=r^2\frac{d^2x}{dt^2}\Big/M$. As r and x are lengths, the dimensions of k are l^3t^{-1}. We know that $k=\frac{1}{3862}$. This value does not change when we pass from the centimetre and gramme to the metre and ton. There is only one time interval, the second, for which $k=\frac{1}{3862}$, and only one unit, θ, for which k becomes 1. If we adopt that unit, k disappears from the expressions for F, which become $F=\frac{Mm}{r^2}$, $F=m\frac{d^2x}{d\theta^2}$. The relation between k, t, θ, is $kt=\theta$, that is, k is the numerical value of the old unit as function of the new unit, for which the Newtonian constant has unit value. In analogy to natural and common logarithms, the author speaks of natural time. To pass from natural time to any arbitrary common time, we must introduce a coefficient k which is the measure, in absolute value, of the arbitrary unit of time to be adopted. The author exemplifies such calculations. The duration in absolute measure of a pendulum oscillation follows from $\Theta=2\pi\sqrt{\frac{l}{\gamma}}$, where γ denotes the mass M of the earth divided by the square of the radius a; hence $\Theta=2\pi\sqrt{\frac{1}{\frac{4}{3}\pi\cdot5\cdot5}\cdot\frac{l}{a}}$. The length of the pendulum l which would make 3,600 oscillations in a natural hour can be deduced from $\frac{1}{3600}=2\pi\sqrt{\frac{1}{\frac{4}{3}\pi5\cdot5}\frac{l}{a}}$, whence $l=1{\cdot}02960m$ for Paris. These examples suggest a new method of determining k, which we know as the square root of the Newtonian constant. We calculate the duration of a movement, due to attraction, suppressing k in this calculation; we observe the movement in seconds, and divide the former value by the latter. The quotient will be k. Dividing, for instance, the value for Θ for a second pendulum by 2 (period of two seconds), we obtain $\frac{1}{3862}$. From observations of the moon, we find $k=\frac{1}{3864}$. In this way the exactness of formulæ can be checked. As regards the geodesial pendulum and the mass of the earth, compare Abstract No. 4, 1899. H. B.

1464. *Physical Constitution of the Moon.* **Lœwy** and **Puiseux.** (Comptes Rendus, 129. pp. 5–8, July 3, 1899.)—The authors, in presenting to the Academy of Sciences the *fourth* part of the large photographic Atlas of the Moon, which they are compiling from photographs taken at the Paris Observatory, offer suggestions as to the information these photographs give concerning the state of the lunar surface. C. P. B.

1465. *Equations in Planetary Theory.* **H. Ludendorff.** (Göttingen Nachrichten, 4. pp. 345–348, 1898.)—This is a purely mathematical paper, dealing with certain equations of condition in the theory of the minor planets as affected by the perturbations caused by Jupiter, and is really a continuation of a more elaborate paper given by the author in 1897. C. P. B.

1466. *Influence of Moon on Seismic Movements.* **U. Landi.** (Revista Scientifica, 30. pp. 237–239, 1898.)—The author debates whether there is any relation between the astronomical position of the moon and seismic movements. He states that "many earthquakes occur at '*equiluna*' and at '*lunistizio*,' that is when the moon is in the plane of the equator or when at the greatest distance from it, or when the sun and the moon have the same declination." A. Gs.

1467. *Density of the Earth.* **F. Richarz** and **O. Krigar-Menzel.** (Zeitschr. Instrumentenk. 19. pp. 40–56, 1899, also Abhandl. der Berl. Akad. 1898.)—Description of the balance used for measuring gravitational attraction, alternately above and below a 100-ton mass of lead, in the recent Berlin Academy and Prussian Government experiments (see 1899, Abstract No. 232). The value obtained is $5{\cdot}505 \pm 0{\cdot}009$. A. D.

1468. *Earth Tremors and Mercury Reflectors.* **G. Bigourdan.** (Comptes Rendus, 128. pp. 1147–1149, 1899.)—The article commences by stating the importance of being able to measure an image reflected from a mercury surface (as giving the only absolute method of determining the astronomical vertical), and the many difficulties encountered in such observations by reason of the vibration of the earth's surface. It has been suggested that these might be eliminated by observing at a depth below the surface of the ground, and the author has made experiments to test the idea, working at various depths and with mercury baths having varying thicknesses of film.

He finds evidence of two distinct types of tremors, which may be distinguished both by the depth at which they die out and their different effect on the reflected image. He describes one type as "undulations," the other as "vibrations."

"Undulations" cause very slow and regular movements of the reflected image, their duration varying from 0·25 to 0·5 second, with a mean amplitude of 2 or 3 seconds of arc during the day, but some attain an amplitude as great as 10 or 12 seconds arc; their direction is not constant but may take successively all orientations.

"Vibrations" are much more rapid and irregular, it being impossible to measure their duration, amplitude, or direction, but it is evident that their amplitude is much less than that of the undulations.

As regards their effect on the image, the undulations cause the reflected image to move, but, being so slow, do not obliterate it, while the vibrations entirely destroy the definition and render identification impossible.

The author finds it difficult to ascribe any single cause to explain these phenomena. He has compared the behaviour of the mercury surface at different depths below the surface of the ground, during various hours of the day, in Paris, and in the country, quite remote from habitations or traffic. From the facts observed he thinks it probable that the undulations are caused by displacements of large weights, such as passages of trains, heavy waggons, &c., while the vibrations are caused by the integration of smaller disturbances, and that it may be possible to greatly improve the conditions of reflection observations if they are made at some distance below the surface of the ground. C. P. B.

1469. *Helmholtz's Theory of Sun's Heat.* **T. J. J. See.** (Science, 9. pp. 737–740, 1899.—Paper read before the Philosophical Society of Washington, May 13, 1899). The first portion of the paper consists of a summary of the conclusions deduced by Helmholtz for the amount of heat produced by the shrinkage of the sun's mass. The remainder gives in a discursive manner the present author's application of "Lane's Law" to estimate the probable duration of the sun's heat. His conclusion is that the future duration of the sun's heat can hardly exceed four million years, and consequently a corresponding limit is set for the continuation of animal and plant life upon our globe. C. P. B.

LIGHT.

1470. *Source of Monochromatic Light.* **C. Fabry** and **A. Perot.** (Comptes Rendus, 128. pp. 1156–1158, 1899.)—Sodium light has serious disadvantages, and the authors recommend the mercury arc light in vacuo, discovered by Arons; that is, the arc produced between mercury and mercury in a Torricellian vacuum in a ∩ tube or, in the pattern employed by the authors, in an outer closed tube and an axial open-ended tube. A shake of the apparatus completes the circuit by a splash of mercury and sets up the arc; and that the arc may be stable, a voltage of at least 30 volts is required. The principal radiations are: (1) violet, $\lambda = 0{\cdot}33580\mu$, cut out by yellow glass or a thin layer of bichromate of potash solution; (2) green, $\lambda = 0{\cdot}54607\mu$, cut out along with the preceding by a weak solution of eosine; (3) two yellows, $\lambda = 0{\cdot}57696$ and $0{\cdot}579066$, cut out by a few millimetres of a concentrated solution of chloride of didymium; and a mixture of this solution with bichromate of potash cuts out all except the green rays. The violet ray is very useful for photographic work; for this the yellow and green need not be eliminated, but it is necessary to interpose an acid solution of sulphate of quinine in order to get rid of some ultra-violet radiations. For lantern purposes the arc may be struck, in air, between mercury (+) and carbon (−); the lines are less fine than with mercury vacuum tubes, but they enable most optical experiments to be performed with mono-chromatic light. A. D.

1471. *Refractive Index of Pure Water.* **C. Bender.** (Wied. Annalen, 68. 2. pp. 343–349, 1899.)—The author determines the refractive index of pure water for the hydrogen lines Hα, Hβ, and Hγ, by means of Pulfrich's refractometer, in which a cube takes the place of the prism. He finds that between 10° and 40° the refractive index of pure water is the same as that of water containing air. The alteration of the refractive index with the temperature is given by the following formulæ:—

$$H\alpha = 1{\cdot}3323004 - 0{\cdot}0001129\left(\frac{t^\circ}{5}\right) - 0{\cdot}0000419\left(\frac{t^\circ}{5}\right)^2$$

$$H\beta = 1{\cdot}3382118 - 0{\cdot}0001129\left(\frac{t^\circ}{5}\right) - 0{\cdot}0000419\left(\frac{t^\circ}{5}\right)^2$$

$$H\gamma = 1{\cdot}3414389 - 0{\cdot}0001129\left(\frac{t^\circ}{5}\right) - 0{\cdot}0000419\left(\frac{t^\circ}{5}\right)^2$$

for temperatures between 10° and 40° C. E. E. F.

1472. *Telescopic Objective for Spectroscopic Use.* **C. S. Hastings.** (Amer. Journ. Sci. 7. pp. 267–270, 1899.)—Following on the lines of papers in the Amer. Journ. Sci. (see vol. xxxvii., 1889), the author announces that he has succeeded in making a four-glass objective with two free surfaces and an aperture of $f/10$. The focal plane is rigidly the same for all wave-lengths from A to K, and the colour correction is complete, even including chromatic difference of spherical aberration. The name suggested for this combination, whose action is the same upon light of all wave-lengths, is an isokumatic system. The optical work has been under the care of Mr. Brashear, of Allegheny. A. D.

1473. *Interference Fringes on Daguerreotypes.* **O. Wiener.** (Wied. Annalen, 68. 2. pp. 145–148, 1899.)—Interference plays a considerable part in the Daguerre process of photography. The interference is produced by the thin layer of silver iodide deposited on the silver plate. The author has demonstrated the existence of a periodic variation of the sensibility with the thickness of the deposit. He prepared a double wedge-shaped layer of the iodide by laying a silver plate on a wide glass tube and exposing both to the action of iodine vapour. The layer of iodised silver increased in thickness from the line of contact outwards. The plate thus prepared was exposed to the spectrum of an arc lamp produced by a slit normal to the line of contact. The developed plate then showed two or three fringes running parallel to the line of contact. On cutting another plate through in a direction normal to the line of contact, exposing and developing one half only, and observing the other through a blue glass, it was found that the interference fringes seen through the glass coincided with the fringes produced by the blue rays of the spectrum. This is in accordance with Daguerre's instruction to produce the layer having a yellow tinge, which absorbs the blue rays best. There is therefore a maximum whenever a ventral segment of the electric force coincides with the surface. E. E. F.

1474. *Daguerreotype as an Interference Process.* **H. Scholl.** (Wied. Annalen, 68. 2. pp. 149–182, 1899.)—The turbidity which plates of pure silver iodide acquire under the influence of light is not due to a chemical change but to a mechanical subdivision of the exposed layer, the final product being pure silver iodide, as before. This process requires the catalytic aid of oxidising substances such as oxygen, iodine, and the like. When Daguerre plates are exposed, the silver plate becomes iodised, and the silver iodide is reduced from the outer surface downwards. That the plates can be developed at all is due to the metallic silver at the surface.

The Daguerre plate possesses a maximum sensitiveness when the conditions for the reduction of the iodide are most favourable, *i.e.*, when the ventral segment of the stationary light waves lies in the surface of the iodide which is in contact with the air. This reacts upon the inner portions of the film. When a layer of iodide is enclosed between two transparent platinum mirrors, and is illuminated by violet light, it becomes the seat of an E.M.F., which shows that the iodine migrates to regions of least luminosity. A somewhat similar observation is made when the iodide is illuminated from the air side and from the silver side respectively, and the differences in behaviour are studied.

E. E. F.

1475. *Pressure Due to Radiation.* **W. Donle.** (Wied. Annalen, 68. 2. pp. 306–315, 1899.)—Various attempts have been made to determine the pressure to which the vanes of a radiometer are subjected owing to the radiation which impinges upon them. Schuster in one case found a pressure of 0·0294 dyne on a surface of 1 square cm., weighing 0·03 milligramme. The author has obtained some interesting results by means of a bifilar balance. For a Hefner candle he obtained 7×10^{-5} dynes per square cm., for a stearine candle 12×10^{-5}, for an Argand burner 75×10^{-5}, and for an Auer burner 45×10^{-5}. Various bifilar arrangements were used, but the best was that in which a bar of aluminium 1 mm. wide and 2 cm. long, was suspended by two cocoon fibres, and provided with a mica vane at one end and a glass counterpoise at the other. By a slight difference in the length of the two fibres it was ensured that the mirror attached to the bar always returned to the same zero. The results, especially at the higher vacua, are fairly in accordance with those of Crookes. An interesting question put was whether Röntgen rays produce any such pressure. In one experiment slight indications of pressure were obtained, but nothing definite could be concluded from them. E. E. F.

1476. *Absorption of Light in the Magnetic Field.* **A. Righi.** (N. Cimento, 9. pp. 295–302, 1899.)—The influence of an appreciable breadth in the absorption bands causes the colour of the light which appears on closing the circuit not to be complementary to that transmitted. Experiments with bromine and iodine previously unsuccessful have succeeded upon using thinner layers of the vapours. (See also 1899, Abstract No. 424.) A. D.

1477. *Correlation of Zeeman Effect.* **O. M. Corbino.** (Roma R. Accad. Lincei Atti, 8. pp. 250–254, 1899.)—Admitting that the curve of absorption for a circular ray is, with the

exception of its displacement, the same as before, and that among the constants of a medium which determine the absorption by that medium are comprised all those which determine the index of refraction; it follows that the phenomena of anomalous magnetic rotatory polarisation with all their peculiarities can be deduced from the Zeeman phenomenon. So also can the symmetry of the phenomenon, with the aid of Helmholtz's anomalous-dispersion postulates; and so also can the double refraction by absorbent vapours, normal to the lines of force.

A. D.

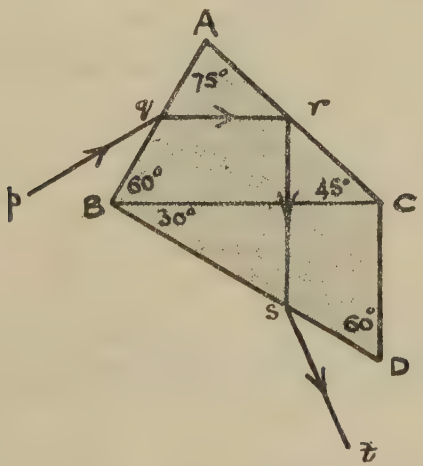
1478. *Theory of the Zeeman Effect.* **W. Voigt.** (Wied. Annalen, 68. 2. pp. 352–364, 1899.)—Since the observed deviations from the "normal" type of Zeeman effect lie in the behaviour of the component, which, in the wave propagated normally to the lines of force, is again polarised normally to the lines of force, they are due to the anomalous behaviour of the component of the electric force which is parallel to the lines of force of the magnetic field. Following up this clue, the author works out modifications of the Hertzian equations which account for the quadruplets of Cornu and Becquerel, and allied forms.

E. E. F.

1479. *Magneto-Optic Phenomena.* **T. Preston.** (Nature, 60. pp. 175–180, June 22, 1899.)—This is a reprint of the author's Royal Institution lecture of May 12th. The portion on Complex Atoms deals with the natural grouping of the lines of certain metals in triplets, each triplet being supposed to be due to a different ion composing the atom. Not only do the lines of the various metals range themselves in similar groups, but the corresponding lines of the different spectra are *similarly* affected by the magnetic field. And further, not only is the character of the magnetic effect the same for the corresponding lines of the different metals of the same chemical group, but the actual magnitude of the resolution as measured by the quantity e/m is the same for the corresponding series of lines in the different spectra. This leads to the surmise that the ion which produces the lines A_1, A_2, A_3, &c., in the spectrum of zinc is the same as that which produces the corresponding series, A_1, A_2, A_3, &c., in cadmium, and the same for the corresponding sets in the other metals of this chemical group. In other words, not only is the atom a complex composed of an association of different ions, but the atoms of those substances which lie in the same chemical group are perhaps built up from the same kind of ions, or at least from ions which possess the same e/m, and the differences which exist in the materials thus constituted arises more from the manner of association of the ions in the atom than from differences in the fundamental character of the ions which build up the atoms; or

it may be, indeed, that all ions are fundamentally the same, and that differences in the value of e/m, or in the character of the vibrations emitted by them, or in the spectral lines produced by them, may really arise from the manner in which they are associated together in building up the atom. E. E. F.

1480. *Spectroscope of Fixed Deviation.* **P. Pellin** and **A. Broca.** (Journ. de Physique, 8. pp. 314–319, June, 1899.)—The paper commences by considering the disadvantages of the usual plan of obtaining fixed deviation by introducing a reflecting surface into the prism train (first suggested by Fuchs, and later developed fully by Wadsworth), the chief of which are the possible lack of definition of the silvered mirror and its non-permanent nature. The authors then proceed to describe a plan for so designing a prism that the rays shall, after being refracted, undergo a total internal reflection before emergence, this being then equivalent to the previous system of prism and subsidiary mirror. The suggested form of prism, giving a constant deviation of 90°, is shown in the figure, the path of a ray at minimum deviation being also indicated.

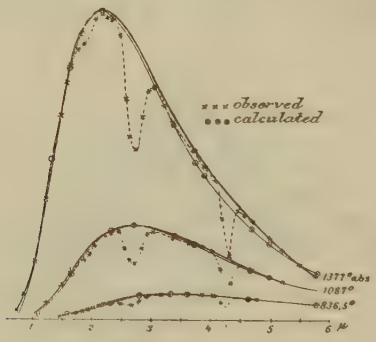


Successive wave-lengths from red to ultra-violet may be viewed in the centre of the field of the telescope by simply rotating the prism, the central ray being always at minimum deviation.

If greater dispersion than that given by one such prism is insufficient, several of similar construction may be used in series, and diagrams are given in the article showing the various dispositions of the apparatus which follow by using two or more prisms. C. P. B.

1481. *Magneto-Optic Phenomena.* **P. Drude.** (Verh. Deutsch. Phys. Gesell. 1. pp. 107–116, 1899.)—Systematic development of the equations. In metallic vapours, magnetised, the Hall effect is in every case of essential importance for the production of magneto-optic effects, while molecular currents are not so; the reverse being the case in the strongly magnetisable metals, iron, nickel, and cobalt. But the Hall effect, or the molecular currents, as the case may be, predominate over but do not exclude one another; both always contribute to some extent to the effect produced. A. D.

1482. *Energy in the Spectrum of a Black Body.* **O. Lummer** and **E. Pringsheim.** (Verh. Deutsch. Phys. Gesell. 1. pp. 23–41, 1899.)—The authors test the various formulæ for the distribution of the radiant energy of an "absolutely black" body, consisting of a uniformly heated hollow space provided with a small opening. The results for three different absolute temperatures, as compared with Paschen's formula, are given in the diagram. They show that within the unavoidable errors of the



measurement of temperatures the distribution is correct, and the maximum energy increases as the fifth power of the absolute temperature. (See also 1899, Abstract No. 1348.) E. E. F.

1483. *Absorption Spectra of Gaseous Mixtures.* **P. Baccei.** (N. Cimento, 9. pp. 241–253, 1899.)—The author shows that the absorption due to a gas is the same whether it is alone or mixed with another gas, provided density and pressure remain the same. This means that the absorption due to a mixture of several gases is the sum of the absorptions due to the gases taken singly.
E. E. F.

1484. *Spectrum Analysis.* **N. Lockyer.** (Nature, 59. pp.

535–539, 1899.)—The article is a review of the facts leading the author to adopt the theory of dissociation of matter with regard to temperature, in the course of which details are given of the laboratory experiments undertaken with the object of testing the hypothesis. C. P. B.

1485. *Currents Traversing Röntgenised Gases.* **W. Hillers.** (Wied. Annalen, 68. 2. pp. 196–232, 1899.)—The author has made a series of careful experiments concerning the manner in which the pressure of the gas between two plates affects the current which passes when they are brought to different potentials, and X-rays are allowed to traverse the gas. He finds, first of all, that the moisture of the gas does not affect either the potential or the current intensity. The course of the potential is embodied in the formula

$$V = \frac{bp}{c(p+c)}$$

where p is the pressure, b/c the potential at high pressures, and c the pressure at which the resistance reaches a maximum. The current intensity varies near c as the square root of the pressure. The conductivities of air, CO_2, and H_2, are in the ratio of 1 : 1·18 : 0·50, but the potential in the case of hydrogen is probably affected by an occlusion of hydrogen in the metallic places. The author has arrived at a pretty close valuation of the comparative case of dissociation of hydrogen and air, *i.e.*, at the comparative numbers of ions dissociated in unit volume under unit pressure when under the influence of the same Röntgen radiation. The ratio is 0·29 : 1, the dissociation of air being unity. For CO_2 the dissociation is very nearly the same as that of air. E. E. F.

1486. *Mechanical Action during Röntgen Radiation.* **F. Neesen.** (Verh. Deutsch. Phys. Gesell. 1. pp. 69–73, 1899.)—Shows that the onset of Röntgen radiation is simultaneous with the development of a retarding force which brings to rest a rotating electrode consisting of a pair of vanes, metal on one side and mica on the other. A. D.

1487. *Absorption of Röntgen Rays by Air.* **J. Trowbridge and J. E. Burbank.** (Elect. Rev. N.Y. 34. p. 259, 1899.)—Difference between the rays transmitted through a column of air, 30 inches thick at 4 mm. pressure, and those transmitted through an equal column at atmospheric pressure could not be detected by the fluoroscope. A. D.

HEAT.

1488. *Thermal Expansion of Pure Nickel and Cobalt.* **A. E. Tutton.** (Roy. Soc. Proc. 65. pp. 161–162, June, 1899.)—The author has examined specimens of nickel and cobalt, specially purified by means of nickel carbonyl, with the interference dilatometer (Abstract 1017, 1898) between 6° and 121°. The coefficients of linear expansion α are :—

For nickel .....$\alpha = 0{\cdot}00001248 + 0{\cdot}0000000148\ t$
For cobalt .....$\alpha = 0{\cdot}00001208 + 0{\cdot}0000000128\ t$

T. E.

1489. *Boiling-Point of Hydrogen.* **J. Dewar.** (Proc. Chem. Soc. 15. pp. 70–71, 1899.)—By a rhodium-platinum resistance thermometer, and by the use of methods designed to get over the difficulties arising from the presence of air in the hydrogen, the boiling-point was determined as $-246°$ C. A constant volume hydrogen thermometer working under diminished pressure has given $-252°$ C. The pure platinum resistance thermometer gave $-238°$ C. A. D.

1490. *Tempering of Glass.* **L. Marchis.** (Journ. de Physique, 8. pp. 193–206, 1899.)—The author verifies experimentally one of the foundations of Duhem's theory of the secular changes of glass and the displacement of thermometer zeros. He shows, among other consequences, that if instead of producing an abrupt cooling from T_2 to T_0 during a disturbance, the thermometer is maintained for some time at a lower temperature, T_3, the glass is tempered to the same extent as it would be by a disturbance at the temperature T_3. E. E. F.

1491. *Some Applications of Molecular Volumes.* **A. Leduc.** (Annal. Chim. Phys. 17. pp. 173–196, 1899.)—By molecular volume is here meant the function ϕ which occurs in the author's form of the characteristic for gases, viz.—

$$Mpv = RT\phi,$$

wherein M is the molecular weight, T the temperature on a scale starting from $-273{\cdot}2°$ C., and R a constant for all gases. This function, determined empirically by the study of a certain number of gases in particular conditions, was generalised by means of the principle of corresponding states. (See 1898, Abstracts Nos. 300 and 383.) Assuming its absolute correctness, the author applies it to test the exactness of various determinations of the densities and specific volumes of certain saturated and non-saturated vapours,

viz., isopentane, ether, carbon disulphide, and water. He then applies it to the case of vapours that are anomalous by reason of dissociation or polymerisation, especially chlorine, nitrogen-peroxide, and acetic acid, and concludes that, though Natanson's experiments on chlorine cannot be said to fully confirm Gibbs' theory of dissociation, they amply justify it; but he insists on the necessity of calculating the density of a gas or vapour by his formulæ and not directly from its molecular weight. In a post-script he gives 15·88 as the atomic weight of oxygen. R. E. B.

1492. *Maxwell's Theorem.* **P. Saurel.** (Journ. Phys. Chem. 3. pp. 214–216, 1899.)—This purports to be a generalised demonstration of the theorem that the total area of the cycle formed of an actual and the corresponding theoretical isothermal is zero: it starts from Gibbs' equation. R. E. B.

1493. *Modification of Van der Waals' Equation.* **L. Boltzmann** and **H. Mache.** (Wied. Annalen, 68. 2. pp. 350–351, 1899.)—The modified formula is—

$$\left(p\mathrm{T}+\frac{a}{v}\right)\left(v-\tfrac{1}{3}b\right) = r\mathrm{T}\left(v+\tfrac{2}{3}b\right)$$

It has the advantage of yielding values for p of the order of magnitude

$$\left(v-\tfrac{1}{3}b\right)^{-1}$$

i.e., infinite, when v is nearly equal to $\frac{1}{3}b$. The theoretical results are compared with Amagat's values for carbonic acid. The agreement is not very satisfactory, especially for the lower temperatures, but is in any case better than that obtained by Van der Waals. E. E. F.

ELECTRICITY.

1494. *Electrification of Air.* **Kelvin, M. Maclean,** and **A. Galt.** (Phil. Trans. 191. pp. 187–228, 1898.)—A description is given of a series of experiments on the electrification of air and other gases, in which three different methods were employed: (1) Observation of electrification of the substance receiving the electricity equal and opposite to that taken by air; (2) observation of electricity of a hollow metal vessel into which electrified air is introduced, or from which electrified air is removed; (3) observation of the electricity taken out of air by the electric filter. An account of the results obtained by method (1), in which air and other gases become electrified when blown in bubbles through water or solutions of salts, has been formerly published. The electrification of the air was negative. By method (2), experiments here described have determined approximately in absolute measure the total quantity of electricity in a given mass of electrified air; and it has been found that the greatest electrification which could be communicated to a large quantity of air by needle-points supplied with electricity from an electric machine, was $3{\cdot}7 \times 10^{-4}$ c.g.s. electrostatic units per cc. While this is the greatest electric density obtained by the authors with needle-points, a density of 22×10^{-4} c.g.s. electrostatic unit was obtained by an electrified hydrogen flame.

In the first experiments with method (2) the apparatus consisted of a metal can, 48 cm. high and 21 cm. in diameter, supported by paraffin blocks, and connected to one pair of quadrants of a quadrant electrometer. It had a hole at the top to admit the electrifying wire, which was 531 cm. long, hanging vertically within a metallic guard tube, which latter was connected to the other pair of quadrants of the electrometer, and to its sheath and to a metallic screen surrounding it. During the experiment one terminal of the electric machine is connected with the guard-tube and the other with the electrifying wire, which is tipped with needle-points or tinsel, placed nearly in the centre of the can. The can is temporarily connected to the sheath of the electrometer. The electric machine is then worked for some minutes so as to electrify the air in the can. As soon as the machine is stopped the electrifying wire is lifted clear out of the can. The can and the connected quadrants are disconnected from the sheath of the electrometer, and the electrified air is very rapidly drawn away from the can by a blowpipe bellows, arranged to suck. This releases the opposite kind of electricity from the inside of the can, and allows it to place itself in equilibrium on the outside of the can, and on the insulated quadrants of the electrometer in metallic connection with it. It was found that one needle and four minutes' electrification gave as great electrification as could be obtained. A modification for quickly

removing the air from the can was adopted, and the greatest electric density found for the air was, as stated above, $3{\cdot}7 \times 10^{-4}$. Other experiments on electrification of air, by water-jet, and by an insulated water-dropper at different potentials, are described. On raising the temperature of the air the electrification diminished.

Air, and other gases, were shaken up with water, and with solutions of different substances, and the electrification produced in the gases measured. The largest value obtained was that in the case of coal-gas from a pressure cylinder shaken up with water, in which the quantity of electricity found in the gas per cc. was (in c.g.s. electrostatic units) $0{\cdot}42 \times 10^{-4}$ neg.

Different gases were electrified by needle-points and flames, the gases being drawn through an electric filter consisting of a block-tin pipe with two brass gauges and one plug of cottonwool between them. When the air in a glass cylinder was electrified by six needle-points the remarkable result was found that short times of electrification at 5,000 volts gave greater values as indicated by electrometer and filter than longer times of electrification. Similar results were obtained with carbonic acid gas, a nearly perfect annulment of the electrification by ten minutes of the electrified needle-point in carbonic acid, and by five minutes in air, being noticed. The explanation suggested is the production of a conductive quality in the gas by continued electric disruptive action.

The results of tests of the efficiency of various filters are given.

The current of electricity from an electrified needle placed in the centre of a jar coated inside with strips of tinfoil was measured, first with different pressures of the air, the potential of the needle being constant, and next with constant pressure of the air while the potential of the needle was varied. In the first case the current through air from needle to metal of jar became greater as the pressure of air became less, down to the lowest pressure observed, viz., 4 cm. In the second case, while the current increased regularly for increasing potential of the needle, the current with the same air-pressure is greater for negative than for positive electrification. A certain minimum potential of the needle is necessary before any current is shown. Also it was found that air at a given pressure was electrified to a greater extent by a certain potential of the needle than by other potentials higher or lower. J. J. S.

1495. *Break-up of a Discharge.* **H. Abraham.** (Comptes Rendus, 128. pp. 991–994, 1899.)—Experiments showing how a high tension deflagrator discharge, with flame, may be broken up into intermittent flame discharges by lowering the inducing current, or by blowing air through the flame. In the latter case the discharges are equal, and their frequency is proportional to the strength of the inducing current. A. D.

1496. *Electrolytic Actions near Crookes Tubes.* **H. Bordier and Salvador.** (Comptes Rendus, 128. pp. 1511–1512, June 19, 1899.)—This investigation was undertaken to explain the effects of Crookes-tube discharges on the skin, which have been attributed to X-rays. It is found that an electromotive force of polarisation is set up between two plates of copper or of zinc immersed in a solution of the sulphate of the same metal, the whole being contained in a tube placed near the excited Crookes tube. The electromotive force persists even after the tube of liquid has been screened from X-rays; its amount diminishes with increased distance from the Crookes tube, and its direction corresponds with that of a discharge between the anode and the kathode, the circuit of which is completed by the liquid. On increasing the resistance of the Crookes tube, the electrolytic effect becomes more marked, although the intensity of the X-rays is smaller. The authors attribute the effects on the skin to these electrolytic actions. J. L. H.

1497. *Velocity of Electric Waves.* **G. V. MacLean.** (Phil. Mag. 48. pp. 115–131, July, 1899.)—Electric waves about 6 metres long are generated by an oscillator, and detected by a resonator of exactly the same form and size, and which is really a specially devised coherer. By reflection, stationary waves are obtained and their length measured by detection of the nodes and loops. The period of the waves was determined by photography of the spark. The result obtained is: $v = 2{\cdot}991 \times 10^{10}$ cm. per sec., or about 186,365 miles per sec. in air. E. H. B.

1498. *Velocity of Electric Waves along Wires.* **C. Gutton.** (Comptes Rendus, 128. pp. 1508–1511, June 19, 1899.)—Using a Branly tube as a detector, the author compares the velocities of propagation of electric waves along wires and in the air. Within the limits of the errors of observation, viz., about 1 in 200, the two velocities appear the same. E. H. B.

1499. *Absorption of Electric Waves and Electroluminescence.* **H. Kauffmann.** (Zeitschr. Phys. Chem. 28. pp. 673–707, 1899.)—The author makes many generalisations from the work of Drude on abnormal absorption of electric waves 75 cm. long, and his own observations on luminescence of vapours under the influence of Tesla waves: the principal are as follows:—

Abnormal absorption is due to the presence of a weak bond in the molecule, such as is indicated by ready decomposition, oxidation, reduction, &c. For 75 cm. waves a maximum of absorption accompanies a medium degree of weakness. Abnormal

absorption may be predicted; the determining groups, besides OH, are NO_2, N_2O in azoxy bodies, CO.CO, NH in aromatic amines and hydrazo bodies, CH : N : CH, &c.

With Tesla waves, aromatic substances luminesce far more than aliphatic ones: OH and NH_2 have a determining influence, while Cl, Br, NO_2 and $C_2H_3O_2$ oppose luminescence; alkalisation is indifferent. The cause of luminescence is ascribed to a tendency of the benzol ring to pass over into the quinone form.

B. B. T.

1500. *Transparency to Hertzian Waves.* **G. Le Bon.** (Revue Scientif. 11. pp. 513–526, 1899.)—The shortest Hertzian waves yet produced are of 5 mm. wave-length. In Hertz's work the difficulty was to produce waves which could be detected. Nowadays the difficulty is not in producing Hertzian waves, but in avoiding their production. Even to touch anything is enough to produce these waves. When an induction coil is used, the spark must be very short; the frequency is then high, the colour of the spark is different, and one pole of the coil can be touched without pain. The variations of conductivity in a coherer are only an exaggeration of what must occur in every circuit-wire clamped in by binding screws, upon the production of any spark in its neighbourhood. This can be readily shown by measuring the resistance of a pile of discs of iron, bismuth, or aluminium, before and after passing a spark near it. If the discs be of different metals, shocks will bring the resistance up to 30,000 ohms, and a spark will suddenly reduce this to 3 ohms. Copper wire does not produce this effect; if iron wire had been more generally used, Ohm's law might not have been discovered, for making and breaking the circuit itself makes sparks sufficient to produce the disturbing effect referred to. And more than this, the neighbourhood of copper seems to prevent this effect, so that a pile of alternate discs of copper and aluminium obeys Ohm's law.

Metals are apparently not nearly as opaque to Hertzian waves as was at first thought; but if the enclosure be perfect the waves do not get through. The apparent transparency is due to the waves getting through chinks or round the metal; but if there be no chinks, a thickness of $\frac{1}{100}$ mm. is as effectively opaque as one of 2 mm., and forms a perfect screen, so that waves cannot even travel down a metallic rod into the interior of a perfectly closed box. A chink is much more effective in allowing rays to pass through than a much more considerable series of apertures; and metallic gauze is very nearly as opaque as a plate.

The length of the waves makes them turn round obstacles with great facility: which accounts for the apparent partial transparence of metallic mirrors.

Non-metallic substances have been considered to be perfectly transparent. But do the Hertzian waves come through a hill

or round it? 12 cm. of Portland cement are partially opaque, 30 cm. wholly so. Dry sand is almost completely transparent, wet sand much less so. Freestone is much less opaque than cement; but it becomes more so when wet. These bodies are far more transparent for Hertzian waves than for light, but the transparency varies from one body to another, decreases as the thickness increases, and increases when the bodies are wet. The waves therefore come round, not through, a hill.

If we put together: (1) a 25 cm. induction coil; (2) a spark-gap and two Leyden jars; (3) a solenoid coil connecting the two Leyden jars; (4) a large coil of copper wire; (5) two wires leading from the ends of the solenoid (3), one to the lowest point of the coil (4), the other to a point of the same to be found by trial and error; (6) a wire leading from the top of (4), and with a free tip; then on setting (1) in action, sparks pass in (2), and an oscillating current in (3), which current is partly taken through (4), and there affected by self-induction, so that a large "brush" is formed at the tip of (6), and this brush traverses dielectrics freely without deviation (therein differing from the ordinary electrostatic brush), and in the dark can be seen to do so. This bombardment ruins a Geissler tube as if it had been riddled with small holes; but the explanation of the phenomenon is still to be found. The photo-plate shows that the phenomenon extends to a considerable distance beyond the visible glow of the brush. At two metres distance a Geissler tube will glow up. The whole field of the brush seems to become a rapidly oscillating electrostatic field. A distribution-table within it at some distance, when the induction coil had a 50 cm. spark actuated by a 110 volt current, was covered with sparks; the wires fused and short-circuited, and a conflagration was started. If this brush could be concentrated upon a warship, it would be caught up by the electric wires and would cover them with sparks which would soon cause an explosion. The same effect could no doubt be produced upon ammunition stores, and even the contents of soldiers' cartridge belts. A. D.

1501. *Capacity.* I. I. Borgman and A. A. Petrowski. (Comptes Rendus, 128. pp. 1153–1155, 1899.)—Columns of liquids, good conductors, have the same capacity as equal columns of mercury. Columns of liquids, bad conductors, have the same capacity as mercury columns when their heights are very small, but the capacities become less in proportion as the heights increase, and tend asymptotically towards limiting values. Columns of liquid insulators (anhydrous ether, xylol, solution of alcohol in ether up to 22 per cent. alcohol) have no capacity. The capacity of a tube containing a rarefied gas increases as the pressure diminishes, up to a certain limit. The capacity of a series of Geissler tubes or of tubes without electrodes is less than the sum of the individual capacities; and the increase in capacity per single tube

added to the series is less the greater the number of tubes already in series. If an insulated Geissler tube be brought near another Geissler tube, the capacity of the latter is not affected; but if one of the terminals of the former be earthed, the capacity of the latter is greatly increased; and similar results are observed with electrodeless tubes if the one end of one of them be surrounded by tinfoil paper, and this paper be put to earth. A. D.

1502. *Direct Measurement of Electrical Quantity.* **R. Blondlot.** (Comptes Rendus, 126. pp. 1691–1695, 1898.)—At the centre of a long horizontal solenoid is freely suspended a circular coil of a few turns, the solenoid and movable coil being connected in series by means of mercury cups. The earth's field having been compensated, the position of equilibrium of the movable coil when a current is sent through the apparatus is that in which its plane is normal to the axis of the solenoid. When slightly disturbed from this position, the coil will oscillate, the period being given by $T = 2\pi\sqrt{\{I/4\pi nAi^2\}}$, where I is the moment of inertia of the movable system, n the turns per cm. length of solenoid, A the total area embraced by the various turns in the movable coil, and i the current. From this it follows that $iT = \sqrt{\frac{I\pi}{nA}} = \text{constant}$, a result which enables us to measure directly in electromagnetic measure the quantity passed through the apparatus during any given time. This principle has been applied to the construction of electric meters: the movable coil carries a long contact arm, which periodically closes the circuit of a small electromagnet; the latter attracts an armature attached to one end of a straight flat spring, which gives the movable coil a fresh impulse by striking the contact arm. The total quantity which passes through the meter is directly proportional to the number of oscillations (or the number of times the circuit of the electromagnet is closed by the contact arm), and this number is suitably recorded by an appropriate counting mechanism. A. H.

1503. *Electrolytic Conduction without Electrodes.* **H. Behn-Eschenburg.** (Zeitschr. Elektrochem. 5. pp. 402–404, 1899.)—A continuous non-conducting trough is put round the iron core of a transformer, and is filled with a solution of an electrolyte. The trough constitutes an elementary coil, in which the varying magnetic field of the transformer induces currents. The intensity and distribution of these currents is studied by means of a voltmeter connected to exploring electrodes, and the induced E.M.F. is measured by a voltmeter in circuit with an auxiliary coil on the transformer. The experiments carried out with this apparatus show that electrolytic conduction is subject to the same laws as metallic conduction. E. E. F.

1504. *Conductivity of Electric Arc and Metallic Oxides.* **W. B. Burnie** and **C. A. Lee.** (Electrician, 43. pp. 75–79, 1899.)—The authors point out an analogy between the conductivity of the arc and certain metallic oxides. The first point of similarity is that many of the metallic oxides possess, like the arc, what may be called a "negative resistance," that is to say, for certain current values any increase in the current is accompanied by a decrease in the potential difference, or the differential coefficient of potential difference with respect to current is negative. The authors then consider under what circumstances the resistance of a conductor can so depend on temperature that this can be the case; or since the temperature is a function of the watts radiated they find the necessary relation between these and the resistance.

These conditions are—

$$\text{either } \frac{dR}{dW} > \frac{R}{W} \text{ or } \frac{dR}{dW} < -\frac{R}{W}$$

where R is the resistance of, and W the watts radiated by, the conductor. That is, the resistance must either increase or decrease very rapidly with regard to the watts radiated.

The first of these two conditions would give a perfectly stable state, a definite current for a definite potential difference. The second condition gives unstable equilibrium and is the condition fulfilled by the oxides and also by the arc if that has only resistance. In order to obtain stability in these cases it is necessary to put a resistance in series with the conductor the value of which is greater than the "negative resistance" of the conductor.

In regard to the similarity between the nature of the resistance of these oxides and of the arc, the authors investigated whether the "negative resistance" of the oxide is due to a varying back E.M.F. or merely to changes of actual resistance due to changes of temperature. This was done by superposing on the continuous current a small alternating current, and determining certain points on the potential difference and current curves, and it was found that if any E.M.F. existed it was less than $\frac{1}{300}$ of a volt. In consideration of the analogy between the behaviour of the oxides and the arc, it seems likely that by experimenting with currents of a much higher frequency the arc may be shown to be merely a simple resistance; but for conclusive results the frequency must be much higher than the normal frequency of alternating currents produced by a hissing arc. E. C. R.

1505. *Copper Temperature-Coefficient.* **R. Appleyard.** (Elect. Rev. 44. p. 588, 1899.)—Clarke, Ford, and Taylor's tables have the merit of fitting their observed figures, and may replace Matthiessen's, but justice is not done by the paper to the logarithmic law, owing to a possible error in the choice of the logarithmic

rate of interest. The mean of all the rates calculated from every alternate pair of observation-points throughout the "observed" curve should be taken, whereas Clarke, Ford, and Taylor have taken probably the first and last points only. For cable work the straight-line law is quite as accurate as our knowledge of the temperature. [See 1899, Abstract No. 1170.] M. O'G.

1506. *Polarisation in Solutions of Alkaline Sulphates.* **H. Jahn.** (Zeitschr. Phys. Chem. 29. pp. 77–88, 1899.)—The method is similar to that described Zeitschr. Phys. Chem. 26. 385, 1898 (see 1898, Abstract No. 302). Values are given for Na_2SO_4, Li_2SO_4 and $(NH_4)_2SO_4$ at 0° and 40°, and agree well with logarithmic formulæ of the type :—

Polarisation = A + B log (current), where A and B are constants.

B. B. T.

1507. *Clark Cells.* **E. Cohen.** (Zeitschr. Phys. Chem. 28. pp. 723–736, 1899.)—The author has arrived at the same conclusion as Callendar, Skinner, and Griffiths, *i.e.*, that the fortuitous variations of the Clark cell are due to the presence of crystals in the solution. R. A.

1508. *Callendar's Electrical Recording Apparatus.* (Elect. Rev. 44. pp. 582–583, 1899.)—This is a description of Callendar's recording apparatus, which may be described as an automatic bolometer. W. G. R.

1509. *New Resistance Box.* (Electrician, 42. pp. 837–839, 1899.)—This is a description of a new type of resistance box due to Messrs. Gambrell Bros. The resistances are wound on rods which are drawn through holes at the side of the box, and in certain positions contact is made by rings on the rods and brass sleeves let into the holes. W. G. R.

1510. *Oscillographs.* **A. Blondel.** (Ind. Élect. 8. pp. 137–144, 1899.)—The author briefly reviews the history of oscillographs from his first proposal in 1893, and points out the principles of their working and the conditions to be fulfilled. The latter are in short as follows: (1) Short natural period; the frequency of vibration must be at least fifty times that of the subject of examination; (2) damping regulated to the critical value to give aperiodicity; (3) negligible self-induction; (4) absence of hysteresis and eddy currents; (5) high sensibility; (6) brightness of the spot of light. The bifilar and soft iron

types alone are important. The former consists of a coil composed of two wires stretched in a strong magnetic field and supporting a mirror at their centre. In the latter a very small soft iron needle carrying a mirror is suspended in a strong magnetic field, and the coils are fixed on either side of the needle. In each case the whole of the moving parts are immersed in a bath of castor oil, the viscosity of which is adjusted by varying the temperature to the critical condition of damping. The construction of a double oscillograph of the soft iron type, and of the subsidiary apparatus for illuminating the mirrors and observing the curves, is described in detail, with numerous illustrations. The natural frequency of vibration of the needles is about 6,000 per second, and the curves for a forced frequency of 50 per sec. are accurate to 1 per cent. To obtain the time ordinate, a disc with radial slits rotates in front of a vertical slit, in synchronism with the applied frequency; the vertical slit is illuminated either with an arc or with an incandescent filament parallel to the slit. The screen is of ground glass in a blackened tube; but a telescope may be used to view the image of the curve directly, or a photographic plate may be substituted and exposed by an instantaneous shutter. The synchronous motor consists of a light flywheel carrying strips of soft iron on the circumference and rotating before two electromagnets excited by the current under examination. (See also 1899, Abstract No. 829.) A. H. A.

1511. *New Method of Using Galvanometers.* **Féry.** (Comptes Rendus, 128. pp. 1392–1393, June 5, 1899.)—On account of the great sensibility that can be given to galvanometers with a moving coil, when the controlling force due to torsion is very weak, the zero keeps shifting and the deviations become uncertain, thus preventing the ordinary deflection methods for determining the current through them being used. The author proposes to measure the current by shunting the coil of the galvanometer with a low resistance and noting the speed at which it moves.

The author works out the theory mathematically and arrives at the following result when the moment of inertia of the coil is very small:—

$$E = K\left(v_1 + \frac{v_0 + v_2}{2}\right),$$

where E is the potential difference at the terminals of the galvanometer, v_0, v_1 and v_2 the respective speeds of the coil before, during, and after the passage of the current. This method is analogous to those employed in calorimetry, where the rate of heating is corrected by the observation of the rate of cooling before and after the measurement. The apparatus used by the author had a coil of 30 ohms, it weighed about 3 grams, and was suspended by a silver wire 0·032 mm. diam. and 60 cm. long. A difference of

potential of 0·000001 volt at its terminals, giving a current of 0·00000003 ampere in the coil, produced a corrected speed of the spot of light of 6·75 mm. per minute. Experiment shows the absolute proportionality of the speeds to the currents for speeds varying from 6 mm. to 600 mm. per minute.

E. C. R.

1512. *Kathode Rays in Investigating Alternating Currents.* **E. E. Seefehlner.** (Elektrotechn. Ztschr. 20. pp. 120–121, 1899.)—A method is described for studying an alternating current by superposing on its field the field of a regular alternating current of the same frequency, at 90° to the former, and studying the resultant deflecting action upon kathode rays by means of the luminous figures produced. A. D.

1513. *Measurement of Frequency of Alternating Currents.* **C. Kinsley.** (Phys. Rev. 8. pp. 244–249, 1899.)—A vibrating iron or steel strip is loaded with a non-magnetic rider, and the position of this rider varied until its natural period of vibration synchronises with that of the alternate current to be measured. The vibration of the iron strip is produced by an electromagnet, through which the alternating current is passed.

The equation for the frequency is—

$$\frac{1}{p^2} = \mathrm{F}mr^3 + \mathrm{K},$$

where p is the frequency of the alternating current, m the mass of the rider, r its distance from the fixed end of the strip, and F and K constants depending on the iron or steel employed and on the dimensions of the strip. The author claims that much greater accuracy can be obtained by this method than by the method of altering the length of the vibrating strip, as in Campbell's "frequency teller," and gives a case of measurement of a frequency of 133 $\sim$, the length of the strip being 5·35 cm., where it was found easily possible to arrange the strip so that a change of 0·25 per cent. in the frequency required a change of 1 cm. in the position of the rider. E. C. R.

1514. *Alternate-Current Frequencies.* **J. Zenneck.** (Wied. Annalen, 68. 2. pp. 365–368, 1899.)—The author describes a simple and elegant method for exactly controlling the frequency of an alternator. The alternate current is made to produce a rotary field. The kathode beam of a Braun tube is exposed to this field, and its end is thus made to describe a circle. The circle is interrupted twice at every revolution in such a manner as to leave only two dots at the ends of a diameter. This is done

by means of a tuning-fork tuned to unison with the normal frequency, or at least to a multiple of that frequency. While the frequency remains the same, the dots always appear in the same place. But as soon as it changes, the dots advance in one direction or the other along the circumference of the circle. A difference of 0·1 per cent. makes the spots travel round the circle in 10 seconds, and that is easily seen. E. E. F.

1515. *Thermo-electromotive Forces.* **C. Liebenow.** (Verh. Deutsch. Phys. Gesell. 1. pp. 74–80, and 82–87, 1899.)—Take a block of metal, 1 c. cm., supply its upper surface with heat and withdraw heat from its lower: maintain a difference of 1° between these two surfaces. Further, connect both surfaces by an imaginary conductor which neither develops E.M.F. nor offers electrical resistance. Assume that in this conductor a current passes when the heat-flow takes place. Let W be the external work, H the heat transmitted, and τ the absolute temperature; then for the maximum value of W we have

$$dW = (H/\tau)\, d\tau.$$

Then if I be the current strength between the two surfaces and dE the E.M.F., we have $dW = I.dE$; and if R be the whole electrical resistance between the two surfaces, we have also $I = dE/R$. Further if L be the conductivity of the block for heat, $H = L.d\tau$. From these equations we find

$$(dE)^2 - RL\frac{(d\tau)^2}{\tau}$$

But R and L must both be measured on the same system of units; and as 1 Watt-second = 0·24 gramme calorie, if the equation is to be read in electrical units, we must make it

$$(dE)^2 = \frac{R}{\tau} \cdot \frac{L}{0{\cdot}24} \cdot (d\tau)^2$$

or—

$$\frac{dE_{max}}{d\tau} = \pm 2{\cdot}04\sqrt{\frac{RL}{\tau}}.$$

For copper at 15° C., L = 0·8 and R = 0·000001635; whence $dE/d\tau = \pm 0{\cdot}0001375$ volt per degree Centigrade, a value which is independent of the dimensions of the copper, and represents the maximum E.M.F. attainable in copper through the transmission of heat under these conditions. The corresponding value for iron is 154·4 microvolts per degree. The difference between iron and copper then works out as 154·4 − 137·5 = 16·9 microvolts per degree C. Similarly for other pairs of metals. Differences as regards properties along different axes appear to have the effect of

preventing the complete conversion of the heat passing into the energy of current: and this may have the effect of making the actual current produced—*e.g.*, with bismuth in the couple—differ greatly from the possible maximum as calculated above.

Now let i be the strength of any current passing in the conductor, and h the quantity of heat passing any cross section per second. Then from the preceding, $h = 0{\cdot}24.i\tau.d\mathrm{E}/d\tau$; and for an isothermal system of conductors collecting current through different substances to one point, at that point the heat developed per second will be—

$$\Delta h = 0{\cdot}24\tau.\Sigma i.d\mathrm{E}/d\tau.$$

If there is a drop of temperature in a conductor, in an element of length in which the current i enters at τ and leaves at $\tau + d\tau$, the heat developed per second is $dh = 0{\cdot}24i.\tau.\left(\frac{1}{\tau}.\frac{d\mathrm{E}}{d\tau} + \frac{d^2\mathrm{E}}{d\tau^2}\right).d\tau$ whereof the Thomson effect is—

$$dh' = 0{\cdot}24i.\tau.\frac{d^2\mathrm{E}}{d\tau^2}.d\tau.$$

In bad conductors R is large and L usually relatively small. In glass, for example, the value of $d\mathrm{E}/d\tau$ is much greater than in metals: compare tellurium, selenium, and many crystals with dissimilar axes. Antimony or bismuth, crystallised, with a wire connecting terminal and lateral surfaces, give a current so long as the crystal, heated in a lamp, is hotter on the exterior than internally. In tourmaline, which is a good insulator, the potential differences are very high. The same cause would account for the setting up of considerable potential differences in air through which heat is being conducted.

Discussion of the different data of different observers leads to the conclusion that in metals the flow of heat is opposed to the flow of positive electricity. The Thomson effect leads to the same conclusion: this only appears where $d\mathrm{E}/d\tau$ alters with the value of τ. In antimony $d\mathrm{E}/d\tau$ has the greater value at the colder end, so that the current flows opposite to the flow of heat. In alloys the resistance is increased more than the heat-conductivity diminishes, so that $d\mathrm{E}/d\tau$ is on the whole greater in these than in the component metals. In non-metals the flow of heat and the E.M.F. are in the same direction: tellurium 500, selenium 800 microvolts, and the warmer ends are negative. When non-metallic bad conductors are rubbed with amalgam, they are heated and the heated surface becomes negative at the amalgam. When two non-conductors are rubbed together, the one for which RL has the greater value becomes positive (frictional electricity). When two pieces, one warmer, one colder, of the same substance are rubbed together, the warmer one becomes negative. A. D.

1516. *Thermo-dynamics of Thermo-couples.* **C. Liebenow.** (Wied. Annalen, 68. 2. pp. 316–324, 1899.)—The author postulates a direct connection between heat and electricity of a kind such as to necessitate the production of thermo-electric energy whenever heat passes from a point at a higher to a point at a lower temperature. This assumption leads to another, to the effect that every electric current is necessarily accompanied by a thermal current, and the surprising corollary results that an E.M.F. in a metal may force a stream of heat to go against the slope of the heat curve from a lower to a higher temperature. This means that the thermo-electric phenomena are reversible. For the details of this interesting and promising attempt to solve a complex problem, the original paper should be consulted. But it may be said that the author succeeds in arriving at figures with regard to the ordinary thermo-electric current, as well as the Thomson and Peltier effects, which are borne out by experimental data. E. E. F.

1517. *Wehnelt Interrupter.* **A. Le Roy** (Comptes Rendus, 128. p. 925, 1899); **P. Bary** (Comptes Rendus, 128. pp. 925–927, 1899); **L. Kallir** and **F. Eichberg** (Zeitschr. Elektrotechn. Wien, 17. pp. 184–188, 1899; **Satori** (Zeitschr. Elektrotechn. Wien, 17. pp. 218–219, 1899); **P. Villard** (Paris Soc. Franc. Phys. Bull. 130. pp. 4–5, 1899); **E. Thomson** (Elect. World and Engineer, 33. p. 579, 1899); **A. A. C. Swinton** (Electrician, 43. pp. 332–333, June 30, 1899); **C. T. Child** (Elect. Rev. N.Y. 34. p. 295, 1899); **E. Thomson** (Elect. Rev. N.Y. 34. pp. 295 and 311, 1899); **E. W. Caldwell** (Elect. Rev. N.Y. 34. p. 311, 1899); **G. T. Hanchett** (Elect. World and Engineer, 33. pp. 436–437, 1899).—These papers describe various forms of the Wehnelt interrupter, and include a careful examination of the phenomena. The most important observations are those of Kallir and Eichberg, who apply a stroboscopic method to determine the time-interval of interruption, and find it to be of the order of 0·0005 sec.; stroboscopic observations are further made, using the platinum-point first as anode and then as kathode: the time-interval with a point anode is about double that corresponding to a point kathode. Spectroscopic observations of the glow in each case are also described.

The papers of C. Child, P. Villard, A. Le Roy, G. Hanchett, P. Bary, and Satori are mostly concerned with electrical measurements made upon circuits containing a Wehnelt form of interrupter. Elihu Thomson, E. Caldwell, and Campbell Swinton describe modifications of the apparatus, in which the electrodes are separated by a glass partition having a small aperture. The interruption in the electrolytic circuit takes place in this aperture instead of at one of the electrodes. R. A.

1518. *Wehnelt Interrupter.* **J. Carpentier.** (Comptes Rendus, 128. pp. 987–988, 1899.)—It was observed by Armagnat that the potential difference necessary to produce the required intermittence depends to some extent upon the temperature of the dilute acid, and that an interrupter works at less potential difference when the electrolyte is hot than when it is cold. Carpentier therefore surrounds the containing vessel with an air jacket. The electrolyte is poured in at 80° C. or 90° C., and is afterwards maintained at that temperature by the heat generated in the process of working. R. A.

1519. *Wehnelt Interrupter.* **H. Armagnat.** (Comptes Rendus, 128. pp. 988–990, 1899.)—The interruptions produced by the ordinary arrangement of a Wehnelt interrupter and induction coil are not such as to produce reversals in the primary circuit; but oscillatory currents can be obtained by connecting a condenser between the terminals of the interrupter. A 1-microfarad condenser used in this way with a coil giving a 25 cm. spark produces effects similar to those observed with an ordinary make-and-break apparatus. The author shows that in order to explain the oscillatory character of the current in the latter case, it is not necessary to invoke the idea of "electrolytic capacity," but that it is sufficient to assume that at the contact surface of the anode with the electrolyte there exists a resistance which rises and falls with the rising and falling of the local temperature, *i.e.*, that the local resistance is a function of the current. R. A.

1520. *Theory of Wehnelt Interrupter.* **H. T. Simon.** (Wied. Annalen, 68. 2. pp. 273–293, 1899.)—The author claims to have formulated a complete theory of what is erroneously termed the "electrolytic" interrupter. According to him the effect is altogether Joulean, and there is no electrolysis, though there may be chemical disassociation by heat. In Wehnelt's original form of the interrupter there is no considerable resistance to the current, except at the platinum point. There the temperature increases very rapidly at make, and leads to the formation of a gaseous layer which interrupts the current. A mathematical treatment of these conceptions leads to the following formula governing the action of the interrupter:—

$$T = \frac{3}{2}\frac{L\omega}{k} + \frac{C_1 k}{E^2\omega} + C_2,$$

where T is the time of interruption, L the inductance of the circuit, E the E.M.F., ω the anode surface, k the specific resistance of transition, and C_1 and C_2 constants. This formula

enables the observer to determine beforehand the E.M.F. and inductance required for any given period of interruption. If the resistance and inductance are constant, the relation between the period and the E.M.F. is of the form—

$$T = A + \frac{B}{E^2}.$$

This formula, in particular, is very closely borne out by experiment. E. E. F.

1521. *Wehnelt Interrupter.* **P. Spies** and **A. Wehnelt.** (Verh. Deutsch. Phys. Gesell. 1. pp. 53–59, 1899.)—The authors describe the general effects produced by the interrupter in working, and give references to the following papers: Koch and Wüllner (Wied. Ann. 45. pp. 759 and 773, 1892); Hoho and Lagrange (Lumière Électrique, 52. p. 113, 1894); Richarz (Wied. Ann. 39. pp. 71–72, 83–85, 1890; 47. pp. 579–582, 1892; 63. pp. 261–267, 1897); A. Wehnelt (Elekt. Zeitschr. 4. p. 76, 1899). In summarising the phenomena it is shown that (1) if the applied volts are increased the current increases, the rate of interruption increases, and the current-density increases; (2) if the anode surface is increased the current is increased, the rate of interruption is diminished, and the current-density is diminished: (3) if the self-induction of the circuit is increased the current is diminished, the rate of interruption is diminished, and the current-density is diminished. Some discussion has arisen as to whether the diminution in the rate of interruption with increase of self-induction is due to the corresponding diminution of current, or whether it is an independent effect of "electrolytic capacity." When two electrodes dipping into an electrolyte are connected to the ends of a coil into which a magnet is suddenly thrust, a quickly damped oscillatory current is set up in the circuit. The initial current causes a gaseous layer to form about the electrodes; the layer quickly vanishes, but not before the return-current has made its appearance: the layer may therefore be regarded as behaving like the dielectric of a condenser. The "electrolytic capacity" thus introduced is held to contribute to the oscillatory character of the discharge. R. A.

1522. *Effects of Temperature and of Circular Magnetisation on Longitudinally Magnetised Iron Wire.* **F. H. Pitcher.** (Phil. Mag. 47. pp. 421–433, 1899.)—The iron wire specimen, which was 0·127 cm. in dia. and 26·1 cm. long, was magnetised by a solenoid wound on a thin brass tube about 70 cm. long and 2·23 cm. in external dia. The intensity of magnetisation was determined from the deflection of a magnetometer, the direct effect of the solenoid being compensated by a balancing coil.

The broadside-on position was adopted for the test, as this seemed to give better agreement with ballistic measurements than the end-on position. The wire was heated and at the same time circularly magnetised by a current flowing through it. In order to separate the effects due to heat and circular magnetisation, three sets of observations were taken: (1) in a very high vacuum; (2) in air at atmospheric pressure; (3) in a current of water. As regards the effect of heat, the well-known decrease of permeability in strong fields was observed with rise of temperature; it was found that the point of demagnetisation—which occurred in the neighbourhood of 750° C.—was not absolutely sharp, the I–H curve after descending rapidly changing its direction and descending much more slowly until it reached the H axis. With regard to the effect of circular magnetisation, it was found that for weak longitudinal fields the effect was strongly marked, the corresponding longitudinal I being greatly reduced, but that as the field increased in intensity the circular magnetisation produced less and less effect. A. H.

1523. *Nickel Steel.* **C. E. Guillaume.** (Paris Soc. Franc. Phys. Bull. 123. pp. 3–5, 1898.)—The author describes the properties of nickel steel referred to in Abstract No. 1115 (1898). He also discusses the various phenomena from the point of view of variations in the relative proportions of combined and dissolved material, as against that of polymerisation and depolymerisation of molecules consisting of mixed atoms of iron and nickel. A. D.

1524. *Magnet Steels.* **F. Osmond.** (Comptes Rendus, 128. pp. 1513–1516, June 19, 1899.)—In order that a cast steel may make a usable permanent magnet it is necessary and sufficient that the points of transformation be respectively below 350° and above the lowest temperature to which the metal will be submitted (see Abstract No 1203, August, 1899). This condition can be realised (1) by tempering; (2) by adding certain metals, such as manganese, nickel, chromium, or tungsten. The latter, or self-hardening steels, are investigated in the present paper. They are hardened by cooling from a temperature above their point of transformation during heating, and softened on bringing their temperature below that of transformation. The steels investigated contain varying proportions of manganese, nickel, and carbon. They are of interest chiefly because they require no tempering, and their magnetic properties are constant throughout their mass. J. L. H.

1525. *Low Temperatures and Magnetic Properties.* **F. Osmond.** (Comptes Rendus, 128. pp. 1395–1398, June 5, 1899.)—Certain nickel steels and manganese steels show no magnetic properties until they have been exposed to very low temperatures. The phenomenon is analogous to the lowering of the freezing-point of a liquid by dissolved substances. When certain substances are dissolved in iron, the magnetic transformation-point, ordinarily 860° C., is lowered to an extent depending upon the amount dissolved. Most of these steels can be transformed by immersing them in liquid air. A bar of steel 3·8 cm. long and weighing 11·9 gr., made by Hadfield, and containing 0·59 per cent. carbon, 5·9 per cent. manganese, and 3·77 per cent. nickel was unable to attach itself to an electromagnet fed by a current of 5 amperes. After five minutes' immersion in liquid air the metal became magnetic, its lifting force being 1 kgr., and it retained its magnetic properties up to 650°. The effect of the cooling is to increase the permeability and the remanent magnetism, and also to reduce the density. Some specimens, such as Hadfield's 13 per cent. manganese steel and Guillaume's nickel-chromium steels, have their transformation-points lowered to such an extent that they do not become magnetic even at the temperature of liquid air. E. E. F.

1526. *Cast Iron and Steel.* **B. S. Summers.** (Elect. Engin. 23. pp. 654–658, 1899.)—This is an abstract of a paper read before the Iron and Steel Institute. It deals with irons containing silicon, sulphur, phosphorus, manganese, and carbon, and is illustrated with a number of B-H curves, but does not well admit of an abstract. E. C. R.

1527. *E.M.F. Produced in Flame by Magnetic Action.* **R. Blondlot.** (Comptes Rendus, 128. pp. 1497–1498, June 19, 1899.)—If the terminals of a capillary electrometer be connected to two platinum wires, and if the latter be introduced into the edges of the fan-shaped flame of a gas-burner so as to occupy symmetrical positions, no permanent deflection is obtained, but only a feeble oscillatory movement caused by the variations of temperature due to the flickering of the flame. If, however, the flame be placed between two plane pole-pieces of an electromagnet, with the plane of the flame itself parallel to the polar faces, then on exciting the magnet a deflection is obtained. This result may be very simply explained by noticing that the portion of the flame between the ends of the platinum wires is a conductor which is moving normally across the magnetic field, and in which there is therefore an E.M.F. induced by the motion. A. H.

1528. *Dielectro-Magnetic Media.* **V. Boccara** and **M. Pandolfi.** (N. Cimento, 9. pp. 254–259, 1899.)—The authors have studied what they call a "dielectro-magnetic medium" made of iron powder intimately mixed up with paraffin. The iron used was chemically pure, and was suspended in the liquid paraffin as an impalpable powder. After cooling, perfectly homogeneous masses of dielectric were obtained, as shown by the uniformity in the density of different parts. When the percentage by weight of the iron in the mixture exceeds 50 the latter becomes conducting, and it was therefore necessary to confine the measurements of the inductivity or dielectric constant to percentages below that. The method adopted was that of the induction balance, with improvements on Gordon's arrangement. The balance consists of five discs of zinc 4 mm. in thickness, with rounded edges, one of which is movable at right angles to its surface, while the others are held in position by three wires each. The second and fourth discs are connected to the quadrants of an electrometer, and the central one with the electrometer needle. The disc whose inductivity is to be determined is introduced between the first and second disc, and the first (zinc) disc is shifted until balance is obtained. The results obtained show that the inductivity increases more and more rapidly with the percentage of iron. E. E. F.

1529. *Magnetic Properties of the Elements.* **S. Meyer.** (Wied. Annalen, 68. 2. pp. 325–334, 1899.)—The author summarises the attempts that have been made to connect the magnetic properties of the elements with their atomic weights and the periodic law. Königsberger is the author of the most important compilation on the subject, but the author has made some measurements upon the elements themselves instead of solutions of their salts, since the latter introduce the unknown influence of the solvent. Needless to say, the results are very rough, some of them only qualitative in fact. Meyer's table of atomic magnetisms, in which the elements are arranged in the usual periods, show certain interesting peculiarities which distinctly indicate a dependence of permeability upon atomic weight. Thus the elements at the beginning and end of each horizontal series are invariably diamagnetic (Li, Na, K, Rb, Cs; Br, I, Bi), the paramagnetic elements all being grouped in the middle, with a tendency towards the beginning of the series. Sulphur and phosphorus, which are diamagnetic, are the only exceptions to this rule, unless they are taken as ending the second horizontal row. Chlorine really ends it, but its magnetic qualities are quite unknown.
E. E. F.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

1530. *Expansion of Metallic Alloys.* **H. Le Chatelier.** (Comptes Rendus, 128. pp. 1444–1447, June 12, 1899.)—Maxima of curves of fusibility do not correspond to exact equivalent proportions. Coincident with these maxima are maxima of expansion, which are much higher than those corresponding to the pure metals or to the definite equivalent alloy. The most expansive alloy can therefore not consist of a mixture of crystals of metal and alloy, and the inference is that we have in this case to do with a solid solution. Similar results ought to be obtained in regard to micrographic structure and electric resistivity. A. D.

1531. *Properties of Aluminium.* **A. Ditte.** (Annal. Chim. Phys. 17. pp. 145–173, June, 1899.) (See 1899, Abstracts Nos. 847 and 1064.)—An alloy of aluminium with about 3 per cent. of copper when heated to dull redness and then cooled in water becomes roughly crystalline and full of minute cracks, which accelerate the destructive action of solutions containing salt and acids. Aluminium cooking vessels may be subject to treatment of this kind. T. E.

1532. *Applications of Aluminium.* **H. Moissan.** (Comptes Rendus, 128. pp. 895–901, 1899.)—Referring to Ditte's experiments, the author lays stress on the great influence exerted by the purity of aluminium on its resistance to corrosion, and on the importance of excluding the possibility of electrolytic action due to the contact of some other metal with the aluminium. Reports from different officers of the French army are quoted speaking highly of the endurance of aluminium cooking utensils used for military purposes. Tinned or soldered vessels of iron suffer even more when heated to redness than those of aluminium. The author's personal experience of aluminium cooking utensils has been entirely favourable. T. E.

1533. *Atomic Weights of Oxygen and Hydrogen.* **A. Leduc.** (Comptes Rendus, 128. pp. 1158–1159, 1899.)—Synthesis of water gives the ratio 15·88 : 1·00. A density method gave 15·868 : 1·00; but this, when correction is made for the alteration in pressure when the two gases are mixed, becomes 15·878 : 1·000. A. D.

1534. *Vulcanised Indiarubber.* **H. L. Terry.** (Electrician, 43. pp. 160–162, 1899.)—The writer compiles a few scattered opinions as to the cause of the decay of vulcanised rubber, some of which agree with the facts. R. A.

1535. *Affinity of Organic Bases in Aniline (Aminolysis).* **H. Goldschmidt** and **R. M. Salcher.** (Zeitschr. Phys. Chem. 29. pp. 89–118, 1899.)—The partition of acids (HCl, HBr, HNO_3, and o-Nitrobenzoic acid) between aniline and various bases dissolved in the aniline is determined by the rate of conversion of diazoamidobenzol in amidoazobenzol, which is found to be proportional to the concentration of aniline salt. The results are roughly proportional (the factor varies from 6 to 20×10^8) to the coefficients of affinity in aqueous solution. The proportionality between reaction velocity and acid concentration excludes the idea of electrolytic dissociation being the determinating factor. B. B. T.

1536. *Amalgams of Alkali-Metals.* **E. Maey.** (Zeitschr. Phys. Chem. 29. pp. 119–138, 1899.)—The specific volumes of amalgams of sodium, potassium, and lithium are determined. The curves connecting these with composition are found to consist of a series of straight lines, the intersecting points of which are taken to indicate the following definite compounds:—

$NaHg_5$, $NaHg_2$, NaHg, Na_3Hg.
KHg_{11}, KHg_5, KHg_3, KHg_2, KHg.
$LiHg_5$, $LiHg_3$, LiHg, Li_3Hg.

B. B. T.

1537. *Equilibrium of a One-Component System.* **P. Saurel.** (Journ. Phys. Chem. 3. pp. 334-336, 1899.)—This is a continuation of the author's elucidation of Gibbs' thermo-dynamical studies, and will doubtless be very welcome. The stability-theorem due to Gibbs (Trans. Conn. Acad. 2. 390, 1873) is proved by the author in a concise and lucid manner. F. G. D.

1538. *Reaction Velocity.* **R. H. Bradbury.** (Frank. Instit. Journ. 147. pp. 463–474, June, and 148. pp. 65–73, July, 1899.) —A short account of the theory of reaction-velocity, in which the author gives the various types of reactions, the equations applicable to them, and well-known instances where these equations have been found to hold good. The short *résumé* given does not attempt to be exhaustive. F. G. D.

1539. *Dissociation of Nitrogen Peroxide.* **A. Pochettino.** (N. Cimento, 9. pp. 450–454, June, 1899.)—The ratio of the specific heat varies from 1·17 corresponding to N_2O_4, to 1·30, corresponding to NO_2. Slight divergences from the calculated ratio are attributable to temporary dissociations induced by the sound-waves used in ascertaining the value of the ratio. A. D.

1540. *Osmotic Pressure.* **A. Ponsot.** (Comptes Rendus, 128. pp. 1447–1448, June 12, 1899.)—With very dilute solutions of NaCl the value of i is between 1·76 and 1·81, not 2·00. A. D.

1541. *Osmotic Pressure and Osmotic Work.* **C. Dieterici.** (Zeitschr. Phys. Chem. 29. pp. 139–146, 1899.)—A reply to Noyes (Zeitschr. Phys. Chem. 28. pp. 220–224, 1899; see 1899, Abstract No. 1223), with some further considerations on the experimental realisation of a system to determine osmotic pressures directly. B. B. T.

1542. *Boiling-Points of Mixed Liquids.* **J. K. Haywood.** (Journ. Phys. Chem. 3. pp. 317–327, 1899.)—The curve of boiling-points for mixtures of alcohol, chloroform, and acetone with certain of the following, viz., water, benzene, carbon tetrachloride ether, methyl alcohol, and with each other are determined. The curves for acetone-water and acetone-chloroform have a wave form, the first being convex upwards at the acetone end, the latter showing a well-marked maximum at the chloroform end: all other curves are convex downwards: those for ethyl alcohol with benzene, carbon tetrachloride, and chloroform, and for chloroform with methyl alcohol, show a well-marked minimum. The addition of water to ethyl alcohol, or carbon tetrachloride, or methyl alcohol to acetone alters the boiling-point very little. B. B. T.

1543. *Cryoscopic Behaviour of Substances Analogous in Constitution to their Solvents.* **F. Garelli** and **F. Calzolari.** (Roma R. Accad. Lincei Atti, 8. pp. 579–590, 1899.)—Experiments on fusing points of solid solutions in a series of chemically analogous bodies. A. D.

1544. *Heat of Solution.* **J. J. van Laar.** (Zeitschr. Phys. Chem. 29. pp. 159–161, 1899.)—Continuation of the controversy with Noyes (see 1899, Abstracts Nos. 149, 729, and 730). The author maintains that the *integral* (i.e., *integrated*) heat of solution employed by Noyes in the van't Hoff equation connecting

temperature-variation of solubility with heat of solution is incorrect. Van Laar maintains that the *differential* heat of solution at saturation must be used. F. G. D.

1545. *Conductivity of Electrolytes.* **W. Foster, Jr.** (Phys. Rev. 8. pp. 257–281, 1899.)—Determinations are made of NH_4NO_3, $MgCl_2$, $MgSO_4$, $NaNH_4$, HPO_4, NaH_2PO_4, KH_2PO_4, H_3PO_4, $NaOH$, $H_2C_2O_4$, and citric acid in dilutions up to 10,000. The results agree well with those of Loomis on freezing-point depressions. B. B. T.

1546. *Theory of Lead Accumulators.* **F. Dolezalek.** (Zeitschr. Elektrochem. 5. pp. 533-539, 1899.)—The relation between the E.M.F. of a lead accumulator and the concentration (c molecules per litre) is represented by the simple formula $E = 1{\cdot}895 + 0{\cdot}12 \log c + 0{\cdot}001c$, provided the acid is of not more than 2-normal strength. This equation is deduced theoretically by several independent methods and its accuracy is proved by a series of direct measurements. The E.M.F. of an accumulator filled with saturated lead sulphate solution is found to be 1·25 volts at 0°, whence it is shown, by an application of the above formula, that lead sulphate is hydrolytically dissociated to the extent of at least 15 per cent. Similarly, from measurements obtained with an accumulator charged with 0·1 normal alkali the electrolytic dissociation of water is calculated, the value arrived at ($0{\cdot}33 \times 10^{-7}$ mols. per litre) being in close agreement with Kohlrausch and Heydweiller's result ($0{\cdot}35 \times 10^{-7}$).

In the second part of the paper the influence of concentration of the acid on the potentials of the electrodes considered separately is discussed, and experiments are described in which these values were measured against a hydrogen and a mercury sulphate electrode in connection with the accumulator. The results obtained have some interest in connection with the phenomena of self-discharge, and it is calculated that with 50 per cent. acid the waste at the lead plate is five times, and at the peroxide plate three times, as great as with 5 per cent. acid. N. L.

1547. *Theory of Accumulators.* **E. Hoppe.** (Elekt. Runds. 16. pp. 15–16, 1898.)—An account of the actions which take place in secondary cells from the point of view of recent theories as to solution and the movements of the ions. J. J. S.

1548. *Electrolysis of Copper Sulphate Solutions.* **F. Foerster.** (Zeitschr. Elektrochem. 5. pp. 508–513, 1899.)—Some of the

results obtained by the author in conjunction with O. Seidel (Zeit. Anorg. Chem. 14. 106, 1897) are described, and shown to be in full agreement with the observations of Hübl, whose work had previously been overlooked. As regards the physical properties of the electrolytically deposited metal, the brittle deposits obtained from neutral, or slightly basic, copper sulphate solutions are contaminated with cuprous oxide, whilst the dark, spongy deposit yielded by neutral and acid solutions with a high current density probably contains a compound of copper with hydrogen. The most coherent and uniformly crystalline deposits are obtained by electrolysing at a temperature of 35–40° with a kathode current-density of about 1 ampere per square decimetre. Under certain conditions a spongy deposit, containing cuprous oxide, is formed at the anode, and it is suggested in explanation that the cupric ions at the kathode are converted into cuprous ions, which are unstable above a certain concentration, especially in neutral solutions, and are transformed at the anode into cupric ions with the deposition of metallic copper and cuprous oxide. Attention is finally drawn to the marked effect of the presence of minute quantities of organic substances, such as guttapercha and gelatin, on the character of electrolytic copper. N. L.

1549. *Electrolysis of Solutions of Cane-Sugar.* **K. Ulsch.** (Zeitschr. Elektrochem. 5. pp. 539–541, 1899.)—Experiments were made on the electrolysis of cane-sugar in dilute acid and alkaline solutions between platinum electrodes. When sulphuric acid is used the oxidation is by no means complete, only 63 per cent. of the total possible amount of carbonic anhydride being formed after 22 hours at the ordinary temperature, followed by 1½ hour's electrolysis at 100° with a current of about 1 ampere. The addition of manganese sulphate to the acid solution greatly facilitates the oxidation, which is also more rapid and complete in alkaline solutions, barium hydroxide being especially convenient. The carbonic anhydride produced never exceeds, however, 98–99 per cent. of the theoretical amount, small quantities of some unknown organic substances being formed, which escape the action of the current but are readily oxidised by heating with potassium permanganate solution. N. L.

1550. *Electrolytic Carbamine.* **J. Möller.** (Zeitschr. Elektrochem. 5. pp. 463–464, 1899.) The author has found that this compound is obtained on electrolytic reduction of nitrobenzene in an alcoholic solution containing sodium hydrate, without the aid of a diaphragm. The quantities used in one of his experiments were: nitrobenzene, 25 grammes; sodium hydrate, 40 grammes; water, 50 grammes; alcohol, 350 cc. The resulting solution was electro-

lysed with an E.M.F. of 7 to 8 volts, and a current density of 9–10 amperes per sq. decimetre, at a temperature of 60°–70° C., for thirty-six hours. Platinum electrodes were used. Carbamine, aniline, and unaltered nitrobenzene were present in the final solution, but the author was unable to determine the exact yield of the first.

The remainder of the paper is devoted to a discussion of Löb's theory of electrolytic reduction as applied to the nitrobenzene series of compounds. Löb in his investigations had made use of a diaphragm, and the author gives details of further experiments made by himself in order to determine the value and effect of the diaphragm in these reduction processes. J. B. C. K.

1551. *Electrolytic Synthesis of Azo-Compounds.* **W. Löb.** (Zeitschr. Elektrochem. 5. pp. 456–462, 1899.)—After an enumeration of some of the difficulties attending the preparation of these organic bodies by purely chemical methods, the author describes the method of electrolytic reduction used in his experiments. The corresponding nitro-compounds are used as starting-points of the process. Platinum, mercury, or nickel are used as kathode materials. When mercury is used, a large glass beaker is used as reduction vessel; while, when the other metals are used, a clay cylinder is preferable. A strong solution of sodium hydrate is in each case used for the anode electrolyte. The electrolyte in the kathode compartment of the cells is an alcoholic alkaline solution of the nitro-compound.

Precautions are necessary to avoid chemical action on mixing the kathode solutions, in the case of the compound derivatives.

Full details of the application of this general method to the preparation of the following are then given:—

I. *Simple Azo-Compounds.*

o-Azo-toluene. m-Diamido-azo-benzene.
p-Diamido-azo-benzene-disulphonic acid.
Tetra-methyl-diamido-azo-benzene.
p-Azo-toluene-disulphonic acid.

II. *Mixed Azo-Compounds.*

o-touluene-azo-benzene. Azo-toluene-benzoic acid.
m-Sulph-azo-benzoic acid. Amido-azo-benzoic acid.
Amido-azo-sulph-benzoic acid. Dimethyl-amido-benzene-azo-benzoic acid.

J. B. C. K.

1552. *Organic Substitution Products.* **E. Votoček** and **E. Zenišek.** (Zeitschr. Elektrochem. 5. pp. 485–486, 1899.)—The authors have worked out a new electrolytic method for bringing about the substitution of halogens for the amido or diazo groups in benzene compounds. Full details of the application of this

method to the preparation of chloro-benzene; bromo-benzene; o-toluene chloride; p-toluene chloride; and napthalene chloride are given.

To prepare chloro-benzene, a solution of 50 grms. aniline in 120 grms. 30 per cent. hydrochloric acid is treated with 38·5 grms. sodium nitrate in order to obtain the diazo-derivative; 170 grms. copper sulphate are then added, and the resulting solution is electrolysed with an E.M.F. of 12 volts and a current density of 1·6 amperes per sq. decimeter. A copper spiral is used as anode, and a copper foil cylinder as kathode. The electrolyte must be kept at a low temperature by means of ice during the electrolysis. The evolution of oxygen ceases at the end of two hours. 24·9 grms. chloro-benzene (equal to a current effciency of 42 per cent.) were obtained by the authors under these conditions of work.

The other halogen products were obtained in a similar manner, potassium bromide and sulphuric acid being substituted for hydrochloric acid in the case of the bromine derivative.

J. B. C. K.

1553. *Impurities in Aluminium.* **A. Minet.** (Comptes Rendus, 128. pp. 1163–1167, 1899.)—Progress in the electro-metallurgy of aluminium has been accompanied by a notable improvement in the quality of the commercial metal produced, as shown by the following table:—

Composition of the Metal.	In 1890.	In 1893.	In 1897.
	Per cent.	Per cent.	Per cent.
Silicon	0·90	0·25	0·02
Iron	0·40	0·40	0·12
Aluminium.....	98·70	99·35	99·86

Three types of Minet furnace are briefly described. W. G. M.

1554. *Borchers' Carbide Furnace.* (Electrician, 43. pp. 111–112, 1899.)—The disadvantages of the usual type of furnace when used for carbide production are summarised as follows: 1. Loss of carbon dust with waste gases. 2. Loss of carbide by exposure to air in heated state. 3. Loss of heat in fused carbide.

The improved Borchers' furnace consists of a smelting chamber with thin walls enclosed in a water-jacket. The finished block of carbide is left for several hours in the furnace, and the heat which it gives out is utilised for steam generation. By working a series of such furnaces at intervals of two hours or less, a constant supply of heat for steam generation can be obtained.

The carbon required for the formation of carbide is supplied by the electrodes; and the lime is used in the form of lumps, not in a fine powder. When the necessary heat has been attained within the furnace, the lime around the electrodes unites with these to form carbide, and this latter flows away in the fused state. The size of the furnace and the charge of lime are so adjusted that the sides of the smelting chamber are always protected by a layer of unused lime from the action of the intense heat at the centre. The system can be used with either arc or resistance furnaces. Borchers claims for these furnaces that by their use one-fourth of the power hitherto used in carbide production can be saved. J. B. C. K.

1555. *Carbon Electrodes.* **J. Zellner.** (Zeitschr. Elektrochem. 5. pp. 450–456, 1899.)—The results of an extended series of observations are summarised by the author as follows:—

1. The durability of a carbon electrode depends not upon its sp. gr., but upon its structure—that is, upon the resistance which its molecules offer to disintegration by the gases evolved during electrolysis.

Low "porosity" (a term explained in the original paper) is, in general, favourable to durability, but is not an absolute criterion of this quality.

2. Neutral or alkaline solutions are favourable to the life of the electrode. Chlorine alone is not very dangerous, but oxygen liberated in acid solutions is especially harmful.

3. The consumption of carbon within recognised limits depends upon the E.M.F. and intensity of the current. It does not depend upon the form or active surface of the electrode. In other words, carbon consumption and current density are proportional one to the other, when the same electrolyte is used.

4. The life of the electrode is promoted by high electrical conductivity of the electrolyte, and by a low E.M.F. and low temperature of the cell.

5. The life of the electrode is promoted by maintenance of a correct relationship between the electrical resistance of the electrodes and of the electrolyte. J. B. C. K.

GENERAL ELECTRICAL ENGINEERING.

1556. *Bichromate Cell.* **W. Weiler.** (Elekt. Runds. 16. pp. 41–42, 1898.)—A description of a form of bichromate cell in which the positive plate consists of a disc of carbon placed at the bottom of the cylindrical glass vessel containing the exciting liquid (12 parts bichromate of potash to 25 parts of concentrated sulphuric acid and 100 parts of water), the negative plate being a star-shaped block of cast zinc fixed at the centre to the lid of the cell. The carbon has joined to it a carbon rod passing to the top of the vessel with a metal terminal. The arrangement may conveniently be fitted up as a gravity cell, the vessel being partly filled up with a solution of common salt and a mixture of one part of bichromate of potash crystals and two parts of potassium bisulphate crystals allowed to fall in through a tube passing to the bottom. J. J. S.

1557. *Automatic Pneumatic Switch for Accumulators.* (Elektrotechn. Ztschr. 20. pp. 317–318, 1899.)—This device, due to E. Petersen, of Copenhagen, depends for its action on the fact that as a secondary cell is nearing the completion of its charge it gives off steadily increasing quantities of hydrogen and oxygen. The controlling cell of the battery is provided with an air-tight hood in which the gases are collected. A U-tube containing mercury communicates with the hood, and as the pressure of the gas increases the mercury is slowly driven up into the open limb of the tube. The mercury forms part of the main circuit, which it closes by means of two platinum contacts sealed into the tube. At a certain point the descending column of mercury leaves the platinum contact and breaks the charging circuit. Hitherto the arrangement has only been tried in the laboratory, with, it is said, satisfactory results. A. H.

1558. *New Rheostat Switch.* (Électricien, 17. pp. 225–226, 1899.)—This is a description of a switch which enables the various constituent parts of a resistance to be placed either in series or in parallel, thus admitting of a more gradual change of the total resistance in a circuit. W. G. R.

1559. *Safe and Accurate Fuses.* **J. Sachs.** (Elect. World and Engineer 33. pp. 781–782, June 3, 1899.)—This article contains a description of the Noark fuse. The exterior of the fuse simply shows a neat fibre tube, at each end of which is a brass ferrule; these ferrules form the contact terminals, or sepa-

rate contacts of the standard hook type are attached. Inside the casing is a special alloy fuse wire entirely encased in a surrounding material. There is no air in contact with the wire throughout its entire length. The surrounding material and its arrangement about the wire play a most important part. In operation the rupturing of the wire of the fuse simply results in the combination between the metal of the wire and the surrounding material, resulting in the formation of a stratum of insulating material between the terminals. W. G. R.

1560. *Reconstructed Granite as an Insulator.* (Electrician, 43. p. 183, June 2, 1899.)—Maine granite is crushed, moulded into form, and fused at 3,000° F. It resists all but hydrofluoric acid, crushes at 14,560 lb. per square inch, and gives a tensile strength of 480 lb. per square inch; 56,600 volts were required to pierce $\frac{1}{4}$ inch of this material in the shape of cup insulators. M. O'G.

1561. *Maximum Demand Meter.* **E. S. Halsey.** (Elect. World and Engineer 33. pp. 628–629, 1899.)—The author describes an attachment to a Thomson integrating wattmeter to indicate maximum watts. The upper or motor part of the meter carrying an indicator or pointer is flexibly coupled to the lower portion carrying the retarding copper disc, which disc carries a kilowatt scale; a pawl and ratchet prevent relaxation of the spring coupling, and a viscous dressing at the junction of the upper and lower shaft acts as a retarding agent and permits sluggish action. The armature torque is always proportional to the load passing through the meter, regardless of speed of rotation, even if the drag disc were stuck so that it could not move; the drag is always equal to the torque whether the meter is fast or slow, or the magnets are weak or strong; the two parts are coupled by a spring, the amount of tension of which is always equal to the strain supplied. E. C. R.

1562. *Differential Rate Meter.* **L. C. Reed.** (Elect. World and Engineer 33. pp. 676–678, 1899.)—A disc divided by radial lines into three-hour divisions is driven by a clock mounted on the top of the meter case. The shaft, which usually carries the index pointer for the initial or primary dial of the integrating train of the meter, is extended from the front of the dial-plate a sufficient distance to carry a disc-shaped cam, the cam portion being in the form of a peripheral notch, having a rounded edge. In front of the cam disc is arranged a bracket; this supports a small oscillating spindle, to which is connected an oscillating lever bearing a pencil or stylus in such a manner that the lever bearing on the disc cam keeps the pencil from touching the chart disc;

when, however, the lever falls into the notch in the cam, the pencil makes a mark on the dial. The working of the device is obvious, as it will be seen that a fixed unit, equal to one revolution of the initial counting dial, is recorded on the chart at intervals, the distance between the dots being the time consumed in recording this unit. E. C. R.

1563. *Chamberlain and Hookham's Two-rate Meter.* (Electrician, 43. pp. 440–441, July 21, 1899.)—This meter automatically changes to a higher rate when the rate of consumption is increased to any prearranged figure. M. O'G.

1564. *Carbons.* (Amer. Electn. 11. pp. 295–297, June, 1899.) —The National Carbon Company's works at Cleveland, U.S.A., which are said to be the most perfect of their kind, are here described. Electric light carbons of every variety form their staple product, together with every form of electrolytic and battery carbon. The raw material employed is the coke from the oil refineries, being the solid material left in the stills after the volatile oils have been distilled off. The process consists in grinding the coke and mixing it with binding material of special composition. The pencils are formed in two ways, either by placing a weighted quantity of material in moulds with grooves and pressing two of such moulds together under a press, thus forming a number of pencils connected with a thin web, or by squeezing the material through dies from a hydraulic press. The pencils, after drying, are cleaned up and made of uniform length, and then baked for eight or nine days in gas-fired furnaces out of contact with the fire gases or air. Other shapes for electrolysis, &c., are moulded in presses and baked in the same way. The finished articles are classified, great care being taken to get the pencils quite straight. When copper plating is required, it is done in the ordinary way for battery plates, &c., but a special machine has been erected, with which pencils can be automatically plated. They are fed into the apparatus and gripped on to a conveyor so that the projecting ends can be immersed in the copper bath. Illustrations of this machine and of the furnaces, &c., are given. J. L. F. V.

1565. *Installation Estimates.* (Elect. Rev. 45. pp. 126–127, 165–167, and 220–222, 1899.)—Gives methods of arriving at first cost of private and general electric lighting installations, and also some particulars of the working expenses and maintenance of the same. EDITOR.

1566. *Wiring Calculations.* **A. Vallée.** (Électricien, 17. pp. 273–274, 291–292, and 311–313, 1899.)—The chief point considered in these articles is the calculation of the most economical method of wiring consistent with a fixed maximum of heating of the conductors. Methods of approximate calculation are given in specific cases. W. G. R.

1567. *Steering Torpedoes by Hertz Waves.* (Electrician, 43. pp. 112–114, 1899.)—The steering mechanism is controlled by a so-called "selector switch," which allows an electric current to pass either to one or the other of two solenoids which operate the helm. The selector switch works in conjunction with a coherer, and the arrangement is such that, when the coherer is under the influence of Hertz waves, the helm is first put over automatically to "port"; when the Hertz waves cease, the helm automatically rights itself; and when the Hertz waves are once more sent, the helm is put over automatically to "starboard"; or, if it is desired to go to "port" again, two wave-impulses are sent in quick succession. R. A.

1568. *Electric Heating in a Hospice.* (Elect. World and Engineer 34. pp. 138–140, July 22, 1899.)—The new Carmelite hospice on the Canadian side of the Niagara Falls is provided with complete electric heating and cooking apparatus. Three-phase current at 2,200 volts is carried on No. 3 bare copper wire from a supply station distant two miles. It is tranformed to 110 volts by two 30-kw. and one 25-kw. transformers at the hospice. A switchboard with double-throw switches controls two phases of the current, and the third phase is controlled by an adjacent switchboard, and is used for cooking, lights, &c. Power amounting to 100 H.P. is taken by contract, 25 H.P. of which are used for lighting (200–16 cps.), cooking, and heating water, while the remaining 75 H.P. is applied to heating the lower floor of the building, containing eleven bedrooms, dining-room, reception-rooms, and corridor. Each bedroom is $15 \times 12 \times 10$ feet high, and contains one 4 H.P. heater with two heats. The corridor is $120 \times 15 \times 10$ feet high, and contains nine 4 H.P. heaters. The kitchen contains one electric range and three ovens. The range has 6 square feet of heating surface, each square foot consuming 15 amperes and having a two-heat switch. The small ovens take 23 amperes at 110 volts, and the large one 50 amperes. Four 25-lb. roasts can be handled at one time. The pantry has three 5-gallon electric urns for tea, coffee, and hot water. Close to the switchboard are two electrically operated boilers, one holding 400 gallons, the other 150 gallons. The former, which supplies the laundry and baths, takes 120 amperes and has three heats. The latter supplies the kitchen, and takes 125 amperes, being principally used for quick boiling. On the opening day the

kitchen electrically cooked dinner for 250 people. The big boiler will heat water from 60° F. to 212° F. in six hours. The small ovens bake bread in eighteen minutes. The large oven is furnished with a thermometer. The current for water-heating, cooking, and lights costs $25 per H.P., or $625 a year, while the 75 H.P. used in warming the building is secured at about one-fifth of this price per H.P. The plant as a whole requires little care for its operation, and gives great satisfaction. E. H. C.-H.

1569. *Electric Drawbridge Contact.* **E. T. Birdsall.** (Elect. World and Engineer 34. p. 116, July 22, 1899.)—Illustrates and describes the contact device on the drawbridge over the Harlem River, N.Y., one of the largest draws in the world. It is lighted by enclosed arcs, the current for which is conveyed to the approaches by armoured rubber cables connected to the contact device. Flexible cable was impossible, as the draw revolves often in one direction. The device consists of a marble block, in which are turned two cavities, one a circular central opening and the other a circular groove concentric with the central cup. In the centre opening is placed a copper disc and connecting lug; in the annular recess is placed a copper ring, to which a lug is attached. This ring and centre disc with their lugs are bedded in "Edison compound" in the marble block. The terminals attached to the lugs are protected by a second block of marble, having proper recesses, cemented to the upper block with similar compound. The upper or movable part consists of a copper rod carrying a disc on the lower end, surrounded by an insulated copper tube carrying a ring and a thin brass dust shield. The upper ring and disc are adjusted to within one-sixteenth inch of the lower ones and enough mercury poured in to fill the cups nearly to the top of the upper ring. The lower part of the device is not fastened to the bridge structure, but is free to move to accommodate itself to any eccentricity of the draw, being connected to the junction boxes by flexible cables. The upper part is adjustably secured to the draw by means of "Barn" type of trolley hangers. E. H. C.-H.

1570. *Electricity on American Vessels.* **J. McGhie.** (Elect. Engin. 23. pp. 433–436, 464–466, and 532–534, 1899.)—This is an illustrated description of the electrical plant on board certain ships, and it cannot well be abstracted. The coal conveyors of *La Grande Duchesse* and the electric cranes on the *Bremen* are described at some length; the latter are operated by a controller, so arranged that the movements of the single handle correspond with the movements of the load in any desired direction. A. H. A.

GENERATORS, MOTORS, AND TRANSFORMERS.

1571. *Armature Reaction.* **A. Potier.** (Écl. Électr. 19. pp. 241–246, 1899.)—The author criticises a paper written on the subject by Picou, and states that the effect of armature reaction in a continuous current machine depends to a great extent upon the teeth in the case of slotted armatures. He proceeds to calculate the amount of armature reaction in specific cases. He also calculates the effect of auxiliary poles. W. G. R.

1572. *Hysteresis Loss in Armature Core-Discs.* **J. Epstein.** (Elektrotechn. Ztschr. 20. p. 326, 1899.)—The author draws attention to the contradictory results obtained by different experimenters with regard to the effect of frequency on the hysteretic loss per cycle. Thus, Warburg, König, Tanakadaté and Weihe (see Phys. Soc. Abstract, No. 619, 1897) found this loss to be less by 20 to 30 per cent. with alternating currents than with a slowly performed cycle. Hopkinson found practically no difference. Maurain (see 1899, Abstract No. 129) found the hysteretic loss to be independent of the frequency for wires less than 0·5 mm. in dia., and to decrease with increase of frequency for thicker wires. Wien (see 1899, Abstract No. 322) concluded from the results of his experiments that the loss with alternate currents exceeded that determined statically. Lastly, Niethammer (see 1899, Abstract No. 835) found that the hysteretic constant was greater for alternate currents. The author suggests that these conflicting results may in part be due to the simple fact that the behaviour of iron in this respect varies from one specimen to another. He emphasises the necessity of testing core discs under the usual working conditions, and refers to a testing apparatus used by Lahmeyer & Co., which is arranged for testing quantities of 30 kgs. at a time. Tests carried out with small test-pieces are unsatisfactory, as the quality of the iron may vary greatly, not only in different plates belonging to the same lot, but in different parts of the same plate. A. H.

1573. *Mechanical Stresses in Slotted Armatures.* **P. M. Heldt.** (Elect. World and Engineer 33. pp. 699–700, 1899.)—In a slotted armature, the ratio of the actual force on a conductor to the mean torque per conductor is the same as the ratio of the magnetic induction in the slot to the induction in the air-gap. Let l be length of core, w mean width of tooth,

d depth of slot, B induction in tooth, a length of air-gap. Then reluctance of tooth is $\frac{d}{wl\mu}$, and reluctance of that part of air-gap through which this induction passes is $\frac{a}{1{\cdot}2wl}$. The coefficient $\frac{1}{1{\cdot}2}$ represents allowance for increased width of tooth at its face and fringing of magnetic lines. The magnetic flux is wlB, and the difference of magnetic potential between polar face and bottom of tooth is $B\left(\frac{d}{\mu}+\frac{a}{1{\cdot}2}\right)$. The magnetic reluctance of a prism of unit area in the slot is $d+a$, the induction in the slot is $\left(\frac{\frac{d}{\mu}+\frac{a}{1{\cdot}2}}{d+a}\right)$B. Let $v=\frac{\frac{d}{\mu}+\frac{a}{1{\cdot}2}}{d+a}$, that is the ratio of the induction in the slot to the induction in the teeth, then if w_2 is the width of the slot the ratio of induction in the slot to induction in the gap is $\frac{(w+w_2)v}{w+w_2v}$, that is the ratio of the actual force on a conductor to the mean torque per conductor. In a slotted armature Mordey found by experiment that this ratio was 0·1, and in a tunnel armature Houston and Kennelly found it 0·014.

R. B. R.

1574. *Heating of Commutators.* **H. W. W. Dix.** (Elect. Rev. 44. p. 848, 1899.)—It is desirable to make commutators and brushes of dynamos as small as possible, consistent with good working. The author suggests a method of readily determining the most economical size of both to suit any given set of conditions.

The total watts lost by commutation is given by—

$$W=\frac{2k_1C^2}{A}+\frac{pA\,\mu V}{k_2} \qquad (1)$$

where k_1 = contact resistance in ohms per square inch
= 0·003 ohm for copper brushes
= 0·03 ohm for carbon brushes
p = brush pressure on commutator in pounds per square inch = 1·25
μ = coefficient of friction = 0·3
A = total area of the positive brushes in square inches
V = peripheral speed of commutator in feet per minute
C = amperes carried by commutator
k_2 = constant = 22.

Differentiating equation (1) with respect to A and equating, the minimum value of W is given when—

$$A=C\sqrt{\frac{2k_1}{V\mu p}\frac{k_2}{}}$$

The value thus obtained is inconveniently large and as in this neighbourhood a diminution of A produces but small increase in W, the author takes half this value as the most suitable one for practical purposes, and obtains—

$$A = \frac{C}{2}\sqrt{\frac{2k_1 k_2}{V\mu p}}$$

$$= \frac{C \times 0{\cdot}297}{\sqrt{V}} \text{ for copper brushes.}$$

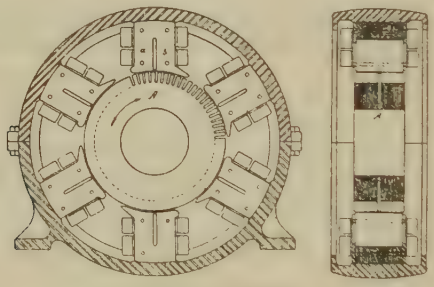
$$= \frac{C \times 0{\cdot}936}{\sqrt{V}} \text{ for carbon brushes.}$$

The values of the constants are taken from Parshall and Hobart's articles in *Engineering*. W. G. R.

1575. *New System of Polyphase Generation.* (Electrician, 43. pp. 236–239, June 9, 1899.)—The method of obtaining polyphase currents from single-phase generators described in the paper is one recently patented by C. P. Steinmetz. Its principle will be readily understood by considering the following example. Let three independently driven single-phase machines be connected in series. The interactions between the machines are, as is well known, such that stability is reached when the sum of the three E.M.Fs. is zero. If the E.M.Fs. are equal, they may be represented by the three sides of an equilateral triangle, the phase-difference between any two E.M.Fs. being 120°. If therefore three conductors be taken from the junctions of the three alternators, three-phase currents may be obtained from these conductors. At the same time, each machine may be supplying its own single-phase load. Similarly, two-phase currents may be obtained from two single-phase machines by connecting them in series with one another and with an induction motor; the latter supplies the E.M.F. which closes the triangle of E.M.Fs., and by suitably adjusting the conditions under which the motor runs any required phase difference between the two single-phase machines may be obtained. The same arrangement may be extended to any number of single-phase machines coupled in series. When the number of machines exceeds three, the polygon of E.M.Fs. ceases to be rigid, *i.e.*, the phase-differences between the various machines cease to be definite; hence it becomes necessary, in order to secure rigidity of the E.M.F. polygon, to break it up into triangles, by introducing auxiliary E.M.Fs. (supplied by an induction motor), represented by the diagonals of the polygon. The system is very flexible, and allows of the supply of polyphase currents to a section of the mains from a power station equipped

only with single-phase machines, this requiring no change whatever in the machines themselves, but merely a slight modification in the switching arrangements and inter-connections. A. H.

1576. *New Generator with Minimum Field Distortion.* **R. Lundell.** (Elect. World and Engineer 33. pp. 518–521, 1899.)—This is a description of a new constant potential dynamo made by the Sprague Electric Company to the following specification: The machine is to be of simple design and of smallest possible dimensions and weight per kilowatt output. It must not heat more than 75° F. above the surrounding air after a continuous ten-hour run at full load. It must be non-sparking at the brushes between no load and 50 per cent. overload, and it must not show injurious sparking at short time overloads of 100 per cent. without change of position of the brushes. The machine must respond quickly to changes of load, and the



CROSS-SECTIONS OF MACHINE

characteristic curve of potentials for various current outputs should approximate as nearly as possible to a straight line. It must necessarily be efficient, durable, and reliable in all details of construction.

The chief features of this machine are the precautions taken to ensure cool and sparkless running.

The accompanying diagrams show the nature of the devices used. Each field-pole is divided into two parts by a ventilating slot and the two halves of the pole differ as regards the polar face, one half being elongated so as to have a much larger polar face than the other half, the result being that the half with the larger polar face becomes saturated before the other half. On increasing the current the part with the larger polar face has its magnetism increased but slightly compared with the increase in the other part. The result is that the distortion of the field is considerably diminished and can be so arranged that the point of commutation is not materially altered. W. G. R.

1577. *Alternate Current Motors.* **C. F. Guilbert.** (Écl. Électr. 19. pp. 161–169, and 208–213, 1899.)—Descriptions of recent patents referring to several types of alternate current motors.
EDITOR.

1578. *Headland's Motor for Electric Vehicles.* (Automotor Journal, 3. pp. 405–406, 1899.)—The chief feature of this motor is that both the armature and the field-magnets revolve at the same speed but in opposite directions; both also act as drivers. This is effected by having two motors on the same axis, the armature of one being rigidly coupled to the field of the other. By use of a hollow shaft the armatures rotate in opposite directions. By the medium of a pinion and wheel for one armature shaft, two driving wheels are obtained rotating in the same direction. Balance of the rotating parts is claimed as well as the absence of need for differential gear.
E. H. C.-H.

1579. *Measurement of Slip in Induction Motors.* **M. v. Hoor.** (Zeitschr. Elektrotechn. Wien, 17. pp. 211–213, 1899. Extract from the Königl. ungar, Akademie der Wissenschaften, March 13, 1899.) — The slip of an induction motor is generally a very small percentage of its speed (being only from 2 to 2½ per cent. in the case of 40 to 50 H.P. motors when fully loaded), so that any attempt to determine the slip by direct observation of the speeds of generator and motor must result in failure. The author describes a number of reliable methods, all of which have been tested by him in practice with satisfactory results. These methods fall under two heads, the first comprising stroboscopic methods, and the second those in which the frequency of the induced currents is determined. In the stroboscopic method, the rotor shaft carries a disc with alternate black and white sectors, the disc being illuminated by an alternate-current arc fed by the generator. The apparent rotation of the disc is a direct measure of the slip. A modification of this method, in which the arc lamp is done away with, and a polariscope is used, is also described. These methods are satisfactory so long as the slip is very small; beyond a certain limit the outlines of the sectors get blurred, and the eye is unable to follow the rapid rotation. Dealing next with methods depending on the determination of the frequency of the currents in the induced system, the author recommends the following method as being the most serviceable: A search coil some 6 or 7 cm. in dia., wound with 300 to 400 turns of 0·2 mm. wire, is connected to a telephone receiver. Round this coil are wound one or more turns of the cable connecting the induced system with the starting resistance. The ear is able to follow much higher frequencies than the eye, and this method is available over the entire range, which is important in practice. When the slip is small, a D'Arsonval galvanometer may replace the telephone.

The following crude arrangement may also be used in the case of large motors (80 to 100 H.P.): Instead of the ordinary short connecting cables between the induced system and its starting resistance, somewhat longer cables are used, two of them being freely suspended close to each other; the current-impulses along the cables set them vibrating synchronously with, and thus afford a means of determining the frequency of, the induced currents. Lastly, in the case of very large motors the slip may occasionally be determined from certain sounds emitted by the motor of a frequency equal to that of the slip. A. H.

1580. *Effect of Wave-Form on Transformer Losses.* **L. Duncan, F. B. Keidel, W. L. Hodges,** and **E. Frank.** (Elect. Rev. N.Y. 34. pp. 264–265, 1899.)—Current curves of various shapes are obtained by the authors by using two separately excited machines attached to the same shaft and imposing a third harmonic upon a fundamental wave. The form of the wave is obtained by plotting the instantaneous values of the voltage. The transformer used is one of the Westinghouse pattern designed for $133\frac{1}{3}$ cycles per second. It is found that the losses are least for peaky voltage curves and greatest for flat curves. W. G. R.

1581. *Transformer Problems.* **C. Heinke.** (Elektrotechn. Ztschr. 20. pp. 175–178, 191–192, and 205–207, 1899.)—An elaborate exposition and critical discussion of the various methods of attacking problems in connection with the alternate-current transformer. A. H.

1582. *Rotary Converters.* **C. Pio.** (Elettricità. Milan. 18. pp. 117–120, 1899.)—This paper treats of the use of rotary converters as tramway generators, and describes some installations where they are employed at the end of a high-tension transmission line. After some discussion of their properties, the author mentions their liability to "hunt" when run in parallel. The General Electric Company, after numerous experiments, succeeded in avoiding this by bridging over the gap between two pole-pieces by a copper plate; the Foucault currents, induced in this, damp the oscillations of the field. The copper plates become hot and occasion a loss of power of about 1·5 per cent. The device is due to a suggestion made by C. P. Steinmetz.

G. H. Ba.

1583. *Practical Applications of Leblanc Rectifiers.* **E. Sartiaux** and **Aliamet.** (Soc. Int. Élect. Bull. 16. pp. 263–287, June, 1899.)—The paper contains an illustrated description of a number of lighting and power plants in which Leblanc rectifiers are made use of. Neither the theory nor the details of construction of the rectifiers themselves are given. A. H.

POWER DISTRIBUTION, TRACTION, AND LIGHTING.

1584. *Polyphase Distribution.* **G. Stern.** (Zeitschr. Elektrotechn. Wien, 17. pp. 114–117, 1899. Extract from Report read before the Internationale Elektricitätsgesellschaft, February 8, 1899.)—A description of the arrangement adopted for the supply of two-phase currents from a central station which has hitherto been furnished with single-phase generators only. A. H.

1585. *Condensers in Alternate Current Power Transmission.* **L. Lombardi.** (N. Cimento, 9. pp. 354–381, 1899.)—The paper is divided into two parts: the first is theoretical, and gives formulæ for the variation of potential in circuits containing capacity, self-induction, and resistance; the second gives the results of measurements, made by the author, of the properties of different dielectrics.

In the first part, besides the usual cases, the author considers those where the dielectric possesses conductivity and hysteresis, where the self-induction medium is iron, where the insulating medium of the circuit possesses a certain conductivity, and finally, the practical case of a transmission line with transformers.

In the second part figures are given of—

1. Disruptive potentials at different distances through different dielectrics in air and in linseed oil.

2. Specific inductive capacities of different dielectrics.

3. Their "figures of merit," *i.e.*, the product of the S.I.C. and the ratio of the disruptive potential of the dielectric to that of air at the same distance.

4. The insulation resistances, and rapidity of polarisation of different condensers.

5. The energy absorbed by different dielectrics.

The author sums up as follows: The characteristic of a dielectric with regard to its practical use in a condenser are:—

i. Its insulation resistance per unit of S.I.C.

ii. Its absorption of energy from leakage and hysteresis (expressed by the author as the sine of the angle of lag which would produce the total absorption).

iii. The rapidity of polarisation (measured by the ratio of the apparent capacities measured by continuous and alternate currents).

iv. The maximum capacity it can present per unit of volume for a given potential difference (measured by the product of its disruptive potential compared with that in air and the dielectric constant).

The proportionate values of these four characteristics as measured by the author are:—

Dielectric.	*i.*	*ii.*	*iii.*	*iv.*
Mica	7,000	0·000	1·007	42
Ebonite	700	0·009	1·021	35
Paraffin wax.....	3,000	0·008	1·021	24
Guttapercha.....	400	0·042	1·050	28
Petroleum	20	0·014	1·7	7
Window glass	2	0·070	2·3	29

Taking the cost into consideration, the author concludes that the most suitable dielectric is paraffin wax, thoroughly free from air-bubbles. G. H. Ba.

1586. *Kootenay-Rossland Power Transmission.* **G. P. Low.** (Journal of Electricity, 7. pp. 69–76, and 85–92, 1899.)—The generating station of this plant has a capacity of 3,000 kw. and delivers three-phase current at 1,100 volts, which is transformed up to 20,000 volts for transmission. Air blast transformers are used and have proved very satisfactory, the arrangements for cleaning the transformers and air-ducts being well thought out. The two pole lines, each 31 miles long, which are fully described in the paper, present many points of interest. On one line both upper and lower cross arms on each pole are roofed, as a protection from the wet snow of the district. Another feature is a clear span of 1,500 feet across the Columbia River, the wires bearing their own weight unsupported by cables. The power is utilised almost entirely in mining and milling works, one mine alone having a 300 H.P. electric hoist driven by an induction motor, a 300 kw. synchronous motor driving a compressor, and many small induction motors for fans, conveyers, &c. The author gives full details of the regulation of the electric hoist which is working very successfully. M. G. W.

1587. *Water-Power in Italy.* **E. Bignami.** (Eng. Mag. 17. pp. 778–789, August, 1899.)—This paper contains tabulated statistics as to the water-power plants installed in Italy during the last ten years, but deals more particularly with the resources not yet developed and the best means of utilising them. The author gives a clear *résumé* of the state regulations as to water grants for power and irrigation purposes. M. G. W.

1588. *Boston Electric Light Company's Station.* (Elect. World and Engineer. 33. pp. 693–698, 1899.)—This new station contains generating plant of 9,400 H.P.

One of the most interesting features is the coal equipment. This includes a movable crane capable of raising 100 tons an hour, driven by a 500 volt motor on the Ward Leonard system, the generator being in the power house and the field rheostat in the crane tower; an electrically driven crusher; and a conveyer of 742 buckets driven by a 15 H.P. motor, which transfers the coal from the pier to the coal pockets. The storage capacity of the latter is 9,000 tons.

Four pairs of Babcock-Willcox boilers are installed, each pair supplying a 2,350 H.P. engine of vertical marine type. The engines are cross compounded and run at 120 revs. per minute; the governors are fitted with special speed-controlling device, which can be set by hand to control the speed through a considerable range for the purpose of synchronising or varying the distribution of load. The dynamos are general electric 60 cycle machines, rated at 1,500 kw. and guaranteed to carry 30 per cent. of overload for any length of time. The revolving fields are 16 feet diameter with 60 outwardly projecting poles, the field winding consisting of edge-wire strip. The external stationary armatures have six slots per pole with three-phase windings generating 2,250 volts.

The switchboard arrangements are very complicated owing to the number of motor generators in use, aluminium 'bus bars, 2 inches by 5 inches in cross section, are used for the three-phase currents.

The article is fully illustrated and contains a detailed account of a very completely equipped station. M. G. W.

1589. *Vienna Five-Wire Systems.* **J. Kolbe.** (Zeitschr. Elektrotechn. Wien, 17. pp. 4–9 and 17–23, 1899; also Zeitschr. des Œst. Ing.-und. Architekt. Ver., 1895.)—A description of two central stations in Vienna working on the five-wire system. A. H.

1590. *Generating Plant and Machinery in the Ivin's Building, N.Y.* (Elect. World and Engineer. 34. pp. 5–8, July 1, 1899.) —Each of the nearly 1,000 offices in this, the largest office building in the world, is electrically lighted, steam heated, supplied with hot and cold water, connected by telephone with an information bureau at the entrance, and has a messenger call-box. In all 7,500 incandescent lamps are used; dynamos having a total capacity of 575 kw., two boosters, a 500 kw.-hour battery plant, 900 H.P. battery of boilers, 1,000 H.P. in engines, 23 electric motors, and 15 elevators of all sizes (see 1899, Abstract No.

1424). To prevent accumulation of condensed steam in the dead-end of the main steam-pipe, a 3-inch pipe is tapped in and used for the pump supply. The drips from the high pressure steam-pipes are carefully collected and used, and the exhaust steam after passing through a grease extractor is returned to the house service lines and the feed-heater. The battery of 58 chloride cells giving 350 amperes for 10 hours, is provided with a ¼-H.P. motor and air-compressor (8 lb. per square inch) for blowing air into the cells to equalise the density. The battery is charged by a booster with shunt and series windings so arranged that at heavy loads the battery discharges. Current for power is taken off inside the compound winding of the dynamos.

E. H. C.-H.

1591. *Dudley and Stourbridge Tramways.* (Elect. Rev. 45. pp. 149–153, July 28, 1899.)—A description of the electrical equipment of this line, which was formerly worked by steam. Three Ball and Wood compound tandem engines with fly-wheels 78 in. × 17 in. face running at 235 r.p.m. are coupled direct to B.T.H. generators, which, with the rest of the installation, are on the usual lines. E. H. C.-H.

1592. *Washington Tramways.* (Street Rly. Rev. 9. pp. 365–373, June 15, 1899.)—All the lines in Washington except those of the Capital Traction Company are being consolidated into the Washington Traction and Electric Company. Through service from the suburbs to any part of the city for a single fare is one of the features. Overhead construction is used in the suburbs; underground conduit in the city. The chief line absorbed is the Metropolitan Railroad Company, which operates 307 cars. Its repair shops are well equipped with machine tools, which are operated by a 20 H.P. motor. The machinery under the cars is cleaned by compressed air-jets at 60 lb. pressure. Every car is overhauled twice a month. The generating station is of the usual McIntosh and Seymour and General Electric pattern. Alongside the feeder panels is an emergency panel, having a water rheostat in series with it. When a short circuit occurs on any feeder it is switched on to this panel and the water resistance varied so as to burn out the short circuit if possible. The fans for the Worthington cooling tower are driven by a special direct-coupled G.E. motor, which has a possible speed variation of 100 per cent. The boilers are connected to a self-supporting steel stack, 6 feet in diameter and 125 feet high.

The conductor rails for the underground system are T-rails, 22 feet long, fastened at their ends and centre to insulators. The plough is 2 feet long by 8 inches wide, built up of steel bars. Two sets of leads from it are provided, one with fuses, one without, the latter being put in circuit when the fuses on the former blow.

The feeders are connected to the rails with special sweated clamps: trouble previously arose through omission of solder.

The Columbia Company, operating 52 cars, has a similar system, with the addition of a plough carriage which is automatically attached to the truck at the end of the overhead system. Some of the other lines receive two-phase current at 6,500 volts from the Potomac Power Company, and transform down in substations to 500 volts direct. E. H. C.-H.

1593. *Accumulator Traction in Bremerhaven.* **Sieg.** (Elektrotechn. Ztschr. 20. pp. 324–344, 1899.)—The line is 4·3 km. long and is worked with accumulators, overhead wires being forbidden in Bremerhaven. Four motor cars and two trailers are in use. The former hold twenty passengers standing and twenty sitting, and weigh seven tons when empty. They carry two 10 H.P. motors with 1 : 4 spur gearing, and batteries of eighty-six cells with four positive and five negative plates, each 20 cm. broad, 30 cm. high, by about 5 mm. thick. The plates are separated by perforated rubber sheets, and the cells are hermetically sealed, provision being made for the escape of gas through a common tube. The whole battery complete weighs 2·5 tons and the car loaded complete twelve tons. One charge suffices for 60 km. The charge put into each car is measured in watt-hours. The conditions are favourable for accumulator working in so far as concerns the absence of hills, but unfavourable on account of the dirty state of the streets and frequent stoppages at the thirty-nine level crossings. Without trailers the energy required was 470 watt-hours of charge per car-km. No actual figures of the cost of maintenance of the batteries can yet be given, but the Cologne Accumulator Company are prepared to maintain the cells for 2·5 pfennigs per car-km. By actual tests of a car on a length of 1 km. the author obtained the following figures on different notches of the controller, the car carrying only three people:—

Notch No.	Energy used per km.	Speed.
3	200 watt-hrs.	10 km. per hr.
4	240 ,,	15·7 ,,
5	260 ,,	17·75 ,,
6	260 ,,	18·3 ,,
7	360 ,,	26 ,,

And with one empty trailer added—

Notch No.	Energy used per km.	Speed.
5	311 watt-hrs.	16 km. per hr.
6	340 ,,	17 ,,

E. H. C.-H.

1594. *Comparison of Electric and Steam Traction.* **B. H. Thwaite.** (Eng. Mag. 17. pp. 415–425, June, 1899.)—A steam

locomotive has to employ half its own tractive force in moving itself on the level. The total costs per ton mile, including supervision, motive and train wages, coal, oil, water, cleaning and repairs of rolling stock, are 0·1245d. on the Liverpool Electric Overhead Railway, 0·190d. on the Manhattan (steam) Railway, 0·152 on the Brooklyn Elevated, and 0·171 for the average American steam locomotive practice. On a train mile basis the relative coal consumption on comparable electric and steam railways is as 16 to 41. The fuel for power at the axle of the electric train does not exceed 2·6 lb. of coal per H.P. hour of tractive effort; in the best steam locomotives this figure would be 3·3 lb.

E. H. C.-H.

1595. *Electric Locomotive of the Paris-Lyons Mediterranée Company.* (Elect. World, 33. pp. 146–147, 1899.)—This company has been experimenting with an electric locomotive for some eight months with a view to electrical operation of the main line from Paris to Melun, with branches totalling sixty-five miles. The body of the locomotive is V-shaped in front. The running gear is on standard French lines, with one idle leading axle and two driving axles. All six wheels are 44 inches diameter; wheel base overall, 20 feet; between drivers, 7 feet. The axle-boxes of the leading wheels are inside and support the load through inclined planes which give the wheels about $\frac{1}{2}$ inch play to either side. The armatures are 27 inches diameter by 22 inches active length, and carry 150 copper bars of $\frac{1}{10}$ square inch sectional area insulated in micanite tubes. They have commutators at each end, each provided with two sets of carbon brushes. The armatures are mounted directly on the wheel axles. A 4 kw. air-compressor operates the brakes, whistle, and controlling devices. A battery of eighteen cells serves for separate field excitation. The main current is controlled by a special water rheostat consisting of an iron box of 60 cubic feet capacity, into which hang twenty lead plates. The bottom of this box is connected with a large reservoir containing carbonate of soda solution and connected with the compressed-air system. The circuit is thus closed through a decreasing resistance by the rise of the solution up the lead plate. When the box is full an auxiliary circuit is closed which operates a short-circuiting switch, cutting out the rheostat. To stop the motors it is only necessary to release the air-pressure on the lower reservoir. This operation is automatically performed by a circuit breaker when the current reaches 1,200 amperes. The fields are separately excited by the auxiliary battery through four mercury switches, by means of which the magnetisation can be reversed to secure reverse motion of the locomotive. All the switches are suitably interlocked. The main battery consists of 192 Fulmen cells carried in a separate tender. Each plate is enclosed in a perforated celluloid envelope, those surrounding the positive plates being internally lined with asbestos cloth.

The positive and negative plates in their envelopes are separated by square rods of celluloid. Each cell has twenty-nine plates, weighing together 175 lb. The capacity of the battery is 500 amperes for $1\frac{3}{4}$ hours.

The results obtained are: Maximum load drawn (including tender but not locomotive itself) 147 metric tons, which were propelled at 30 m.p.h. with the motors in series. A higher speed was impossible without exceeding the safe current from the battery. With the motors in parallel a speed of one mile per minute has been obtained with a load of 100 metric tons. The armatures can carry continuously 700 amperes, which at a speed of 500 r.p.m., equivalent to 60 m.p.h., would require an E.M.F. of 360 volts, the two armatures under these conditions absorbing roughly 500 kw. Estimating their efficiency at 90 per cent. the effective output would be about 611 H.P. By doubling the number of driving motors and wheels the full power of standard steam locomotives could be obtained. E. H. C.-H.

1596. *Train Resistance.* **H. Graftio.** (Street Rly. Journ. 15. pp. 293–297, 1899.)—Many interesting tests on the resistance of trains and of locomotives have been made during the last few years. From experiments made in the United States, A. Sinclair showed that the relation $R=a+bv$ held between the speed limits 60 and 120 km. per hour. Desdouit found that the resistance of locomotive and tender increased very nearly as a function of the speed, of the form $R=a+\sqrt{b+cv^2}$. The author has plotted curves from the data of Desdouit, Privat, engineer of the Paris-Lyons-Mediterranean Railway, Barbier on the French Northern Railway, and Petroff. He expresses the maximum and minimum resistances of a locomotive by the formula—

$$R_{\text{min.}}=5{\cdot}24+0{\cdot}14v-\frac{129}{v},$$

$$R_{\text{max.}}=14{\cdot}38+0{\cdot}12v-\frac{432}{v},$$

which hold between the limits 60 and 95 km. per hour. All the latest experiments seem to prove that the resistance of the locomotive increases very nearly as the speed.

The resistance of the cars only of a train is represented by a curve of a well-marked parabolic form, while the resistance curve of a locomotive is generally of hyperbolic form. Petroff's formula for resistance of cars only is—

$$R=1{\cdot}2+\frac{0{\cdot}6n}{Q}v+\frac{0{\cdot}03}{Q}(1+0{\cdot}004n)v^2,$$

where R is the resistance in kilograms per ton of the cars, Q is the weight of the cars, n the number of cars, and v the speed

in kilometres per hour. The formula was found by careful study of all the causes of resistance, and having established the general form of the equation, Petroff found the most probable values of coefficients from a very large number of experimental data.

The author combines the resistance of the locomotive and the cars and gives curves for the resistance of complete trains. The paper is illustrated by five groups of curves. A. S.

1597. *Electric Motor Cars.* **F. Wilking.** (Elektrotechn. Ztschr. 20. pp. 364–369, 1899.)—A description of the electric 'buses, wagonettes, &c., and trade carts of the Gesellschaft für Verkehrsunternehmungen. The 'bus, holding twelve seated and six standing, weighs complete 3,500 kg. After a journey of 8 km. the cells are charged up in fifteen minutes. E. H. C.-H.

1598. *Electric Motor Cars.* **E. Egger.** (Zeitschr. Elektrotechn. Wien, 17. pp. 58–60, 78–81, and 91–96, 1899.)—The requirements of an automobile in the order of their importance are (1) independence of the driving wheels from one another; (2) smallest possible resistance to motion; (3) easy steering; (4) capability of surmounting all hills; (5) rational weight; (6) sufficient speed and easy regulation of same; (7) economical working. The author then proceeds to discuss the methods adopted for obtaining these requirements, chiefly referring to carriages shown in the Paris automobile show, 1898. The first requirement can be satisfied either by use of differential gear between the wheels or by having an independent motor to each wheel. On an average the relative resistance to motion of pneumatic and iron tires is 100 to 152. Particulars are given of the cells of certain vehicles and estimates of the relative working expenses of electric and horse-drawn carriages. Chauveaux gives the following relation between the power, M, of the motor in horse-power: p, the number of persons carried; v, the speed in kilometres per hour; viz., M/pv=a constant. On this basis the winner of the Marseilles-Nice-La Turbie race, whose constant worked out at 0·11, should only have taken fifth prize, while an outsider, whose constant worked out at 0·034, should have taken first honours. E. H. C.-H.

1599. *A "Torpedo" Motor Car.* (Automotor Journal, 3. p. 347, 1899.)—A car known as "La Jamais Contente" has been built for M. Jenatzy with a body resembling a submarine torpedo-boat. The driver sits in a hole in the rear. The motors, worked from Fulmen accumulators, are direct coupled to the driving (rear) wheels, which are therefore made small in diameter. The car has covered one mile in 61·8 seconds. E. H. C.-H.

1600. *Paris Electric Cabs.* (Automotor Journal, 3. pp. 457–459, June, 1899.)—As a result of the exhaustive cab trials by the French Automobile Club the Compagnie Générale des Petites Voitures, who own 8,500 vehicles and 12,300 horses, decided to gradually abandon horse-traction and adopt electric. The Bersey system, as employed on the London electric cabs, was adopted on account of its simplicity and in spite of the bad appearance of its battery tray. The steering is by means of a pinion working in a wheel on the front axle framing, the pinion-shaft being rotated by the hand-wheel through a worm. This steering gear is sufficiently quick and is irreversible: the front wheels cannot rotate the hand-wheel. Forty-three cells are carried, said to weigh 1,760 lb., but no data are available as to capacity. The makers have a maintenance contract. The motor is by Postel-Vinay, drum-wound with two separate circuits and two sets of magnets. This gives better graduation in speed and provides a standby. The motor weighs 211 lb. and is rated at 3 kw. at 1,500 r.p.m. To one end of the armature shaft is keyed a compressed leather pinion, gearing into the crown-wheel of the differential gear, which is mounted on an intermediate shaft. Upon each end of the latter is keyed a pinion, gearing with the wheels through a "Sebin" chain, which has been adopted in place of the Renolds chains used in London.

The Company have extensive trial grounds with graded roads, dummy obstacles, &c. E. H. C.-H

1601. *Moving Platform Railway of the Paris Exhibition.* **E. Miot.** (Électricien, 17. pp. 177–180, 1899.)—This is a descriptive account of the moving platform railway which is being constructed for the Paris Exhibition of 1900. (See 1898, Abstract No. 338.) W. G. R.

1602. *Precursors of Nernst's Lamp.* **E. de Fodor.** (Zeitschr. Elektrotechn. Wien, 17. pp. 172–178, 1899. Report to the Elektrotechnischer Verein in Wien, March 20, 1899.)—A historical sketch of the gradual evolution of the various forms of incandescent electric lamps. The author points out that Nernst has been anticipated by Jablochkoff, who in 1877 patented a lamp in which a strip of half-baked kaolin ($1\frac{1}{2}$ in. long, 1 cm. wide, and 2 mm. thick) was used as the light-giving portion; and by Edison, who, besides constructing lamps having all sorts of refractory substances for their incandescent portion, actually used a fine platinum spiral for the initial heating of the lamp. A. H.

1603. *Three-Arc 110-Volt Lighting System.* **J. Zeidler.** (Elektrotechn. Ztschr. 20. pp. 241–243, 1899.)—By using special

carbons, between which an arc of sufficient length may be maintained at a P.D. of 35 volts, and an automatic steadying resistance controlled by a coil-and-plunger mechanism, the Allgemeine Elektricitäts-Gesellschaft of Berlin has recently succeeded in running three arc lamps in series off 110-volt mains. The lamp mechanism must be capable of responding rapidly to changes of current, and it is further necessary that the P.D. across the mains should be kept very constant. The lamps used are of the clock type, with hinged clockwork frame controlled by the differential action between a series and a shunt electromagnet.

A. H.

1604. *Arc Lamps.* **E. W. Lehmann-Richter.** (Elekt. Runds. 16. pp. 42–43, 1898.)—A statement of the results of observations on constant current arc lamps, the variations in length of arc, current strength, and potential difference are given, showing the manner of working the lamp and the importance of a system of regulation.

J. J. S.

1605. *Test of an Enclosed Arc Lamp.* **E. Gerard** and **O. de Bast.** (Bull. Ass. Ing. El. Liège, 10. pp. 197–198, 1898–1899.)—The lamp tested was constructed to take 4·5 amperes at 108 volts. The arc was enclosed in a transparent cylindrical globe

Two tests were made: the first with new carbons and clean globe; the second after the lamp had been run for about 103 hours.

The following table gives the results obtained:—

	Test No. 1.	Test No. 2.	
Mean voltage between lamp terminals	108·1	107·4	volts.
Mean current	4·53	4·46	amperes.
Mean power absorbed	489·7	479	watts.
Mean spherical intensity	168·8	129·5	candles (decimal).
Mean hemispherical intensity (lower hemisphere)	199·8	157·5	candles (decimal).
Number of watts consumed per mean spherical candle	2·9	3·71	
Number of watts consumed per mean hemispherical candle	2·45	3·047	

In the calculations one carcel is taken to equal 9·62 candles.

The life of a single pair of carbons is 110 hours and 20 minutes.

W. G. R.

TELEGRAPHY AND TELEPHONY.

1606. *Wireless Telegraphy in the French Navy.* **Tissot.** (Paris Soc. Franc. Phys. Bull. 130. p. 2, 1899.)—Tissot employs platinum electrodes in his coherers. The filings are silver, somewhat covered with sulphide. The current density is kept high, and the tubes are therefore semi-capillary. The receiving wires are not connected to any capacious body, and it is not necessary that they should be vertical, but they should be at right angles to the direction of propagation. M. O'G.

1607. *Telediagraph.* (Elect. World and Engineer. 33. p. 581, 1899.)—This article describes the Hummell apparatus for transmitting pictures by an electrical process. The picture to be transmitted is drawn with insulating ink on heavy metal foil. The foil is then bent once round the horizontal cylinder of the transmitter and is there clamped. There is a similar cylinder on the receiver, and on this are wrapped two sheets of paper with a carbon sheet between them. The transmitting cylinder rotates under a stylus which, when it touches the foil, closes the circuit between the transmitter and receiver. The current through the receiver causes a corresponding stylus to descend upon the paper. A synchronising arrangement keeps the cylinders progressing at equal rates along and round equal screw-threads. The arrangement is an improved form of the Caselli telediagraph. R. A.

1608. *Telephone Engineering.* **T. Spencer.** (Proc. Eng. Club. Phil. 16. pp. 129–144, 1899.)—The author separates the talking system from the signal system in any exchange, and claims supremacy for centralised power stations. A telephone responds to 6×10^{-13} amperes, and by induction between two circuits having one inch of parallel line $\frac{1}{16}$ in. apart (and using standard apparatus) overhearing is complete. The static induction is twenty times the magnetic. Hence the sides of each circuit must have the same insulation and conductivity, and must be raised to the same potential by displacement currents from a disturbing source. Superposed load-diagrams of London and New York telephone exchanges suggest that the use of an Atlantic talking cable might be too small to pay, owing to business hours closing at one place when they open at the other. Curves are given showing the proportion of good calls to busy calls. The importance is pointed out of a subscriber having two telephone lines, so that his own outgoing work may not choke off incoming communications. M. O'G.

1609. *Induction in Telephone Circuits.* **Colard.** (Bull. Ass. Ing. El. Liège, 10. pp. 95–133, 1898–1899.)—The distribution of current and potential in two parallel single wire telephone circuits is mathematically studied, taking account of their resistance, mutual capacity, self-induction, mutual induction, and mutual insulation, uniformly distributed, as well as the resistance and self-induction of the apparatus at the extremities of the circuits. In what follows, i_1 i_2 are the currents in the two wires, and E_1 and E_2 their potentials. The expressions given below for i_1+i_2, E_1+E_2, and i_1-i_2, E_1-E_2, are obtained by a lengthy mathematical investigation.

$$i_1+i_2=\frac{E}{2(R^2+S^2p^2)}\left[R\sin pt-Sp\cos pt\right]$$

$$E_1+E_2=\frac{E}{2}(1-\frac{x}{l})\sin pt+\frac{\Sigma}{2(R^2+S^2p^2)}\frac{x}{l}\left[(rR-sSp^2)\sin pt-(rS-sR\cos pt\right]$$

$$E_1-E_2=\frac{E}{2}\left\{-AS\,hax\sin\left[pt+\beta(x+l)-\phi\right]+BC\,hax\sin\left[pt+\beta(x+l)-\gamma\right]\right\}$$

$$i_1-i_2=\frac{EU}{2}\left\{\begin{matrix}AC\,hax\cos\left[pt+\beta(x+l)-\phi-\theta\right]\\-BS\,hax\cos\left[pt+\beta(x+l)-\gamma-\theta\right]\end{matrix}\right\}$$

The way to use these formulæ arithmetically is indicated in detail, and a useful example worked. Two lines 15 metres high, 30 centimetres apart, having 34·6 ohms per kilometre. From Uppenborn Kalender fur Elektrotechniker, 1898, page 68, the coefficient of self-induction for unit length of wire with earth return is taken as

$$\rho=2\log_e\frac{2h\ (\text{metres})}{r\ (\text{wire radius})}$$

Uppenborn's formula (page 60) for capacity per kilometre in mfds. is

$$\frac{0{\cdot}01206}{\log_{10}\frac{d}{r}}=0{\cdot}0000458 \text{ farads per quadrant in the above example.}$$

The mutual induction coefficient is

$$\mu=2\log_e\frac{2h}{d}=9{\cdot}22 \text{ henrys per quadrant.}$$

From these the current received at either end of the line, both induced and received direct [for various frequencies from 1,000 to 100], is tabulated. The received currents in both lines per volt applied for various lengths of the wires is separately tabulated, and it is pointed out that it is not correct in practice or in theory to simply superpose the effect of electrostatic induction calculated by itself on to electromagnetic induction in order to obtain the total. The simultaneous existence of the two inductions must be

allowed for. The author finds that for lines of moderate length, with moderate frequencies, an exceptionally low insulation between the wires has not the effect of increasing the induction, and leakages due to this cause have only a very secondary effect upon the induced currents. M. O'G.

1610. *Air-tight Cable Conduits.* (Electrician, 43. pp. 124–125, 1899.)—Morten and Kenney propose to use a 6 feet cast iron conduit permanently kept under dry-air pressure, using paper 1,000-wire cables inside it without lead covering; the economy on lead-covered cables drawn into pipes being stated at £11,000 per mile with ten cables. M. O'G.

1611. *Minor Telephone Troubles.* **H. P. Clausen.** (West. Electn. 24. pp. 353–354, June 24, 1899.)—Hand telephones suffer from variations of temperature changing the distance between the magnet and the diaphragm, from the permanent magnet losing its magnetism through accidental heavy currents direct or alternating, and from burned-out or crossed wires. The diaphragms of microphones are liable to break if made of carbon; packing is easily cured by putting in new granules. Hints on rewinding the secondary of the induction coils are given. Magnetos wear at the bearings, at the armature contact-pin, and in the windings. Simple remedies for the above are given. M. O'G.

1612. *Edison's Motograph as a Telephone Repeater.* (West. Electn. 24. p. 361, 1899.)—A rotating cylinder of plaster of Paris moistened with a certain solution is in contact with a strip of platinum, which adheres to it or not according as a current is passing; this increase or decrease of tension is transmitted to a diaphragm which it is proposed to utilise as a transmitter for repetitions. M. O'G.

1613. *Edison's Motograph as a Telephone Relay.* **W. J. Hammer.** (Elect. World and Engineer. 33. pp. 752–754, June 3, 1899.)—Gives details and diagrams of his work on this in 1899. M. O'G.

1614. *Long-Distance Telephony.* **J. H. Winfield.** (West. Electn. 24. pp. 361–362, June 24, 1899. Paper read before

the Maritime Electrical Association at Halifax, April 18, 1899.) —Clearness is more important than timbre and volume and is affected by conditions which alter the position of the waves in regard to each other. It is reduced by static- and self-induction, as these tend to unequally retard vibrations of different periods. Static-induction rounds the top of the waves, losing sharpness. The avoidance of iron wires, the use of leakage, and the crossing of wires are discussed, and various apparatus described.

M. O'G.

1615. *Automatic Call Register.* **H. T. Richards.** (Elect. Rev. N.Y. 34. p. 333, 1899.)—H. T. Richards (of 225, West Twenty-eighth Street, New York) has devised a register, which he places on the subscriber's instrument and at the exchange. Both are moved one number ahead by the operator previous to making connection by projecting a current through them.

M. O'G.

1616. *Telephone Exchange System.* **G. Ritter.** (Elektrotechn. Ztschr. 20. pp. 249–253, 265–268, and 283–286, 1899.)—Details are given of the telephone arrangements at Württemberg. R. A.

SCIENCE ABSTRACTS.

PHYSICS AND ELECTRICAL ENGINEERING.

NOVEMBER 1899.

GENERAL PHYSICS.

1617. *Elastic Properties of Steel Wire.* **A. D. Keigwin.** (Instit. Civ. Engin. Proc. 136. pp. 3–9, 1899.)—The effects of wire-drawing and annealing on the stress-strain diagram of steel wire are here experimentally studied. The conclusions are: 1. Steel when wire drawn has its breaking load increased. 2. When the wire is annealed the breaking load is lowered to that of the billet from which the wire was drawn; in this case an average reduction of 39 per cent. 3. The ratio of yield point to breaking load (36·7 and 31·8 per cent. for unannealed and annealed wires respectively) is lowered. 4. The ratio of the extensions at yield point and at breaking load in unannealed wire, viz., 0·25 to 0·75 per cent., is increased by annealing to 0·25 to 5 per cent. 5. The reduction of area of break is increased 16 per cent. by annealing. 6. The mean stress-strain diagram for annealed wires is a parabolic curve. J. B. H.

1618. *Young's Modulus by Interference-Method.* **G. A. Shakespear.** (Phil. Mag. 47. pp. 539–556, June, 1899.)—Three wires, at equal distances from each other, are attached at their upper and lower extremities to metallic discs, the points of attachment being capable of adjustment. Part of the interference-apparatus is placed on the centre of the lower disc, and part on a suitable stationary support near the centre. The advantage of the adjustable triple suspension is that, when the wires are stretched, the movable part of the interference-apparatus moves parallel to itself. The load is applied without any shock with the aid of a cylinder, pointed at each end, originally immersed in water; removal of water from the containing vessel increases the load, addition diminishes it.

The behaviour of the wires at various temperatures is studied

by surrounding them with jackets of the vapour of water or other liquid, produced at various pressures. Temperature has a remarkable effect on the value of Young's Modulus. In the case, for example, of a specimen of copper, which had rested for some time, it was *increased* by 4·4 per cent. on *first* heating the wires from 13° to 100°; but on allowing them to cool to 13°, and again heating to 100°, there was a contrary behaviour, a *decrease* of 2·3 per cent. taking place. A third heating produced a greater decrease. Ultimately, after successive heatings and coolings, the the copper behaved in a consistent manner, the decrease on heating being about 3·6 per cent. Specimens of soft iron and silver steel showed similar but less decided characteristics.

The paper also contains accounts of experiments on the effects of the magnetic field on the elongations and contractions of iron and steel under various conditions. A. Gs.

1619. *Deflection by Small Loads.* **C. P. Weston.** (Phys. Rev. 8. pp. 297–303, 1899.)—A bar, supported at each end, about 60 cm. long, and 1 cm. × 0·5 cm. cross-section, has part of an interferometer attached to its centre. It is loaded by weights of 0·5, 1·0, 1·5, and 2·0 gms., and the deflections are deduced from the movements of the interference bands. The same bar is loaded by weights up to 200 or 250 gms., and the deflections noted by means of a microscope. With steel, copper, and brass bars the ratios between the small and large deflections are, within the limits of the possible experimental errors, as indicated by theory, *i.e.*, Young's Modulus is the same for the feeble as for the greater strains. A. Gs.

1620. *Elasticity of Glass.* **R. Straubel.** (Wied. Annalen, 68. 3. pp. 369–413, July, 1899.)—That the "elasticity ratio," or the ratio of sectional contraction to longitudinal dilatation, has the value 0·25 for all isotropic bodies, has already been made very doubtful by a number of experiments, although those made on metals are not conclusive owing to the absence of definite proof of isotropism. Cornu's method of determining the elasticity ratio is capable of yielding accurate values if the dimensions of the prism are suitably chosen and the flexure is varied within wide limits. The elasticity ratios of thirty specimens of glass from the Jena glass-works range from 0·197 to 0·319 The moduli of compression, calculated from the moduli of tension and the elasticity ratios, lie between 3,070 and 7,520, and the torsional moduli between 1,840 and 3,290 kg. per sq. mm. A representation of the observed elasticity ratios as linear functions of the percentage by weight is feasible, with an average error of 1·7 per cent., and a maximum error of 5·6 per cent., but the values of the constants cannot all be satisfactorily determined. E. E. F.

1621. *Wrought Iron at High and Low Temperatures.* **R. C. Carpenter.** (Railroad Gazette, 30. pp. 808–809, 1898.)—The tensile strength of wrought iron or steel appears to be a minimum at about 70° F., and increases as the temperature is changed in either direction, becoming about 20 per cent. greater at about 500° F. and at 60° below zero. There are indications of a brittle region at the temperature of steam at 5 to 10 lbs. pressure. Iron at low temperatures, while increasing in strength, retains its ductility. In the case of cast iron the tensile strength remains constant from 70° F. to 700°, decreasing from that point to zero at 1,240°. J. J. S.

1622. *Surface Tension.* **H. Wallbott.** (Wied. Annalen, 68. 3. pp. 496–499, July, 1899.)—The author adduces what he claims to be the first direct optical demonstration of the component of the surface tension at right angles to the wall. It is placed in evidence by observing the interference fringes in the spectrum of light reflected by thin plates backed half by air and half by mercury. Sodium light shows a curvature of the air fringes towards the mercury fringes. The author describes several different forms of the experiment. E. E. F.

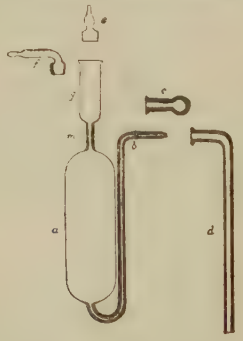
1623. *Viscosity of Liquids.* **G. Wetzstein.** (Wied. Annalen, 68. 3. pp. 441–470, July, 1899.)—The author investigates the variation of the viscosity of liquids under the influence of external pressure, with special reference to deviations from Poiseuille's law. Such deviations were not found to take place as a direct consequence of changes of pressure. But for increasing pressures the Poiseuille formula, including the term introduced by Hagenbach, gives values which are too high, and this deviation is most probably due to a sliding of the liquid along the inner walls of the tube. The external friction appears to be directly proportional to the pressure at the surface of the liquid. E. E. F.

1624. *Impact with a Liquid Surface.* **A. M. Worthington** and **R. S. Cole.** (Roy. Soc. Proc. 65. pp. 153–154, June, 1899.)—This paper is a continuation of a paper under a similar title, published in the "Philosophical Transactions," A. vol. 189, 1897. It contains further descriptions and explanations of the different phenomena experienced when a polished sphere is dropped into a liquid under different conditions as to height of fall, cleanliness of surface, &c. J. B. H.

1625. *Least Thickness of Liquid Films.* **K. T. Fischer.** (Wied. Annalen, 68. 3. pp. 414–440, July, 1899.)—Mercury has, on account of its high surface tension and slight miscibility, great advantages over water in experiments concerning the thinnest liquid films. If olive oil, dilute sulphuric acid, or a mixture of glycerine and water, are spread on mercury, continuous films are generated which may become thinner than 5 mm., or, in the case of the sulphuric acid, 1 mm., without breaking up into drops. But eventually they break up, and the thicker they are the more their breaking up is retarded. E. E. F.

1626. *Maximum Density of Solutions.* **L. C. de Coppet.** (Comptes Rendus, 128. pp. 1559–1561, June 26, 1899.)—The maximum densities of solutions of potassium, sodium, lithium, and rubidium chlorides were studied. The experimental arrangement includes a photographic method of recording the temperatures, which permits a large number of simultaneous observations. The molecular depression of the temperature of maximum density is about 12 for KCl and RbCl, 13 for NaCl, and 6 for LiCl. The figure for lithium chloride is very remarkable. E. E. F.

1627. *Improved Pyknometer.* **A. Minozzi.** (Roma R. Accad. Lincei Atti, 8. pp. 450–452, 1899.)—The author describes an improved Sprengel pyknometer, which is easily filled



by means of the tubes *d* and *f* (shown in the diagram), and stopped by the caps *c* and *e*, and has the advantage that if the temperature of the bath is too high and the liquid escapes, it ascends into the empty portion *g*. It is specially suitable for hygroscopic and volatile liquids. E. E. F.

1628. *Curvature of Surfaces.* **B. Wanach.** (Zeitschr. Instrumentenk, Beib. 7. p. 50, 1899.)—In the ordinary method of

determining curvatures of surfaces by Helmholtz's ophthalmometer or an instrument for measuring angles, it is customary to use an approximate formula obtained by assuming that the angles, sines, and tangents are all equal.

By a transformation of the original formula the author in this paper shows how second and third approximations may be obtained for the radius. J. B. H.

1629. *Artificial Mirages and Tornadoes.* **R. W. Wood.** (Phil. Mag. 47. pp. 349–353, 1899.)—Details of some experiments on the artificial production of mirages. Light was sent through a trough containing layers of liquid of different density, the intermediate layer of liquid having the highest refractive index. A nearly horizontal ray will be bent towards, and will cross, the plane of maximum optical density where it changes its curvature and is again bent towards the plane, which it may cross again and again, traversing a path which is approximately a sine curve. Artificial tornadoes were also obtained by means of precipitated silica sprinkled over a metal plate, which was then heated. These are also well shown when sal-ammoniac is dusted over a heated plate; a miniature tornado of dense smoke two metres high was thus obtained. J. J. S.

1630. *Gravity Balance.* **R. Threlfall** and **J. A. Pollock.** (Roy. Soc. Proc. 65. pp. 123–126, June, 1899.)—Description of a quartz thread gravity balance, probably with a maximum error of 1 in 300,000 in determining the value of g. A. D.

1631. *Production of Waves in an Elastic Solid.* **Kelvin.** (Phil. Mag. 48. pp. 227–236, August, 1899.)—In this, the concluding part (see also 1899, Abstract No. 1120), the author recurs to the case of a rigid sphere of radius g executing harmonic vibrations in an elastic solid. The equations for determining the motion at points in the solid are given, and by the aid of diagrams the gradual transition is shown from the motion $h \sin \omega t$ at the surface of the sphere to that which is found at more distant points. As one of the results obtained, the author rejects his old hypothesis (on the Reflexion and Refraction of Light, Phil. Mag. 1888) of a very small velocity for irrotational wave motion in the undulatory theory of light. S. H. B.

1632. *Deformation of Waves.* **P. Vieille.** (Compt Rendus, 128. pp. 1437–1440, June 12, 1899.)—Intense wav

of compression were produced by exploding gunpowder in an iron tube closed at both ends. Traces of the pressure curves at both ends, and also at two intermediate points, were obtained by means of recording manometers. The powder was exploded at one end of the tube. On comparing the pressure curves taken at the different positions in the tube it appeared that the pressure rose more rapidly in the wave front when it had travelled out than near the origin or point of explosion. The curves, in fact, showed a gradual growth in steepness, with the distance approximating towards discontinuity. The velocity of propagation of the disturbance deduced from the curves was also abnormal, about .600 m. per sec., or nearly twice the velocity of sound.

At the intermediate points in the tube the heights of successive crests on the pressure curves, as the compression passed backwards and forwards in the tube, showed that on reflection at the ends the waves were reinforced in intensity in a conspicuous manner. This is attributed to the gas in the tube being given a general movement in the direction of propagation on the passage of these waves, and then to this movement being arrested by the ends of the tube.

In this way also is explained the curious observations of a somewhat similar nature made by Violle and Vauthier at Grenoble. F. T. T.

1633. *Reflection and Refraction of Elastic Waves with Seismological Applications.* **C. G. Knott.** (Phil. Mag. 48. pp. 64–97, July, 1899.)—This paper consists of three parts. Part I. is substantially the author's seismological paper of 1888, first published in the Transactions of a Tokyo Society which is now defunct. Part II. contains detailed calculations for rock-rock and for rock-air interfaces, similar to those for a rock-water interface contained in the first part. Part III. gives the mathematical investigation and the various formulæ used for the calculations. Stress is laid on the fact that an elastic wave of any type incident upon an interface will, in general, break up into *four* parts, two distortional (reflected and refracted) and two condensational-rarefactional (reflected and refracted). E. H. B.

1634. *Seismometrographs.* **A. Cancani.** (Roma R. Accad. Lincei Atti, 8. pp. 447–450, 1899.)—The author disposes of the objections urged by G. Agamennone against the use of continuous-speed seismographs by pointing out that if the records are taken by means of lampblack instead of ink, even the shortest vibrations of the ground, of a period of about 0·1 sec., can be clearly followed by means of a lens, even though the velocity does not exceed 6 m. per hour. The other objection, viz., that owing to the proximity of the traces they must be confounded as

soon as they are of considerable amplitude, can be met by displacing the slide in a direction normal to the trace as soon as a considerable tremor is announced. E. E. F.

1635. *Microseismograph.* **T. Gnesotto.** (N. Cimento, 9. pp. 454–461, June, 1899.)—The author gives a detailed description of Vicentini's microseismograph with two components as used for the study of the slow movements of the soil, and also instructions for its use. E. E. F.

1636. *Measurement of an Arc of the Meridian.* **Bassot.** (Paris, Soc. Franc. Phys. Bull. 134. pp. 2–3, June, 1899.)—The British, French, and Spanish triangulations cover an arc of nearly 30°, if the French Soudan is included. The arc should, however, be measured under very different latitudes. Russia and Sweden are measuring an arc of 4° or 5° which is more northern than that of Lapland already measured. The Congo basin is not suitable for such measurements, as the landscape offers few points suitable for signal stations. Arrangements are being made for measurements in Ecuador. E. E. F.

1637. *Barometric Determination of Height.* **L. Papanti.** (N. Cimento, 9. pp. 465–469, June, 1899.)—The author simplifies the usual formula for barometric hypsometry by introducing the absolute temperature θ, and obtains

$$A = sq\,\theta\,\frac{P-p}{P+p}$$

He also investigates the influence of temperature generally in the determination of heights by the barometer. E. E. F.

1638. *Atmospheric Tides.* **F. Morano.** (Roma R. Accad. Lincei Atti, 8. pp. 521–528, June, 1899.)—From observations given by a Richard's self-registering barometer at Rome during the years 1891, 1892, 1893, 1894, the author calculates the average variations of the pressure in the course of a lunar day. He concludes: 1. The barometric variation in the lunar day indicates a double oscillation. The two maxima occur about the time of the two culminations; the two minima near the rising and setting of the moon. 2. The amplitude of the oscillation is 0·053 mm.

Assuming the height of the earth's atmosphere to be 300 kilometres, he calculates that the moon produces a tide 21 metres, the sun a tide 10 metres, high. The maximum tide is thus 31 metres. A. Gs.

1639. *Height of Clouds.* **A. Sprung.** (Zeitschr. Instrumentenk. 19. pp. 111–118 and 129–137, 1899.)—This paper gives a description of the automatic photographic apparatus erected at Potsdam for the measurement of the height of clouds on the zenith by simultaneous photography from two stations. The determination of the zenith errors of each instrument by photography of the path of a star is given *in extenso*. The other possible errors are also discussed. J. B. H.

1640. *Lunar Influence on Barometric Charts.* **A. Poincaré.** (Comptes Rendus, 129. pp. 128–131, July 10, 1899.)—Barometric charts have been taken every day throughout several synodic periods, and the results of two of them (March and October, 1883) are plotted as curves to illustrate the relation on the change of barometric pressure with the distance of the moon from the meridian, as shown at varying latitudes on the earth's surface. C. P. B.

1641. *Periodicity in the Weather.* **H. H. Clayton.** (Amer. Acad. Proc. 34. pp. 599–618, 1899.)—The author reviews the various theories on periodicity in the weather with special regard to the influence of the moon and its declination on air pressure, temperature, thunderstorms, auroral frequency, &c. He himself accepts such influences, and assumes that every weather period is rendered complex by the existence of periods which bear the relation of harmonics to the primary, *i.e.*, their length is twice, one-half, one-third, &c., of the length of the primary. Thus he discusses periods of two years, thirty or twenty-nine days, seven days, three and a half days. His temperature curves are not as a rule synchronous with the time curves, but lag behind or lead; the transition he calls a reversal. His own arguments refer to observations made in the United States; the first part of the paper is based upon observations conducted in other countries. H. B.

1642. *Meteorological Registration by Kites.* **L. T. de Bort.** (Comptes Rendus, 129. pp. 131–132, July 10, 1899.)—The utilisation of kites for carrying self-recording meteorological instruments to various heights in the atmosphere was first successfully applied in the United States, and for the last four years L. Rotch has obtained valuable and interesting documents in this way at the Blue Hill Observatory near Boston.

The author's observations commenced in 1897, and in 1898 his apparatus reached a height of 2,000 metres, while this year (1899), in consequence of the use of kites of the Hargrave cellular pattern, they have been able to work at an altitude of from 3,940

to 3,590 metres. They find that the law of decrease of temperature with increase of altitude is different according as the area investigated is one of low or of high pressure; also that in clear weather with high pressure the velocity of the wind decreases with the height, whereas in cloudy weather with low pressure the wind velocity increases at higher altitudes. C. P. B.

1643. *Interference Applied to Metrology.* **A. Perot** and **C. Fabry.** (Astro. Phys. Journ. 9. pp. 87–115, 1899.)—The paper is a translation from the original article in Bull. Astron. 16, 5, January, 1899, and describes the author's now well-known methods of measuring lengths and thicknesses by observing the interference fringes produced between silvered surfaces. C. P. B.

1644. *Temperature and Vapour Gradients in the Atmosphere.* **F. H. Bigelow.** (Amer. Assoc. Proc. 47. pp. 127–129, 1898.) —A discussion of the various formulæ expressing the thermodynamic conditions of the atmosphere. These formulæ are of two types, the exponential and the logarithmic. J. J. S.

1645. *Movement of Terrestrial Pole.* **E. F. Van de Sande Bakhuyzen.** (Archives Néerlandaises, 2. 5. pp. 447–486, 1899.)—The author summarises all the available researches on the question and gives tabular comparisons of the various results obtained by Chandler, Albrecht, and others, showing the present state of the subject. C. P. B.

1646. *The "Green Ray" after a Red Sunset.* **Guébhard.** (Paris, Soc. Franc. Phys. Bull. 131. pp. 5–6, 1899.) — The green ray seen after a red sunset is not subjective, but is the grey shadow of the earth, feebly illuminated from the zenith and viewed by an eye fatigued for red; it therefore appears green. **M. Pellat** says the phenomenon is more distinct; the setting yellow sun has a red lower and a green upper border, separately examinable in the telescope, and due to prismatic refraction by the atmosphere. The absorption which makes the sun's disc appear yellow makes the violet upper rim appear green or greenish blue instead of violet. When the sun sets the upper green rim can be seen for a fraction of a second, but can be kept longer in view if the observer go up a slope as the sun sets. **M. Guébhard** thought this was different from the green ray following the setting of a *red* sun. **M. Raveau** had seen the sea coloured green in a triangle with its apex at the point where the sun set; and the colour seems to flow away towards the horizon. A. D.

1647. *Stellar Radial Velocities.* **F. Schlesinger.** (Astro. Phys. Journ. 9. pp. 159–161, 1899.)—Spectroscopic determinations of velocity in the line of sight are usually given with respect to the sun, but of course the original observation gives the velocity relative to the earth, and for the necessary reduction somewhat lengthy computations have to be effected. To partly minimise this labour, the author has tabulated the corrections to be applied for the different positions of the earth throughout the year, so that any observations may be reduced to the sun without the usual calculations. C. P. B.

1648. *Determination of Stellar Radial Velocities.* **H. Deslandres.** (Astro. Phys. Journ. 9. pp. 167–172, 1899.)—The paper is a reply to a criticism made by Vogel, of Potsdam, on a former paper of the present author. In this article more details are given as to the methods of eliminating errors in the photographic method of determining the velocities of stars in the line of sight. The writer finds the variation of temperature during, say, an exposure of one hour, to be distinctly appreciable, and proposes several methods for attempting to maintain a constant temperature of the spectrograph. The main effect is that the index of refraction of the prisms is changed, this of course manifesting itself in a variation of the dispersion. Electric heating and a continuous circulation around the apparatus have been tried with partial success, and the suggestion is made that a spectrograph specially built of Guillaume's ferro-nickel alloy, with the prisms of zinc crown (this material not suffering a change of refraction with variation of temperature), might be a great improvement on present designs. C. P. B.

1649. *Typical Spectra of New Stars.* **J. Wilsing.** (Berlin Akad. Sitzber. 24. pp. 426–436, 1899). The most striking particular in the spectrum of Nova Aurigæ (1892) was the occurrence of pairs of lines, each consisting of a *bright* line accompanied by an *absorption* line on its more refrangible (violet) edge. The first explanation put forward to account for this was an application of Doppler's principle, the consideration of which necessitated the presence of two aggregations of matter having different velocities in the line of sight, so that the spectrum lines of each were relatively displaced, producing the doubling. Plausible at first, this view presented the difficulty that the displacements of the lines indicated relative velocities of from 1,000 to 1,500 kilometres per second. This fact, together with the observation that no change in the relative positions of the lines occurred for several months led to this simple explanation being doubted.

Other conditions, not involving motion of the light sources, are known to influence wave-length, viz., fluorescence, super

position of different masses of gases at varying temperatures, and varying pressure. In the latter case, the displacement is always towards the red with increasing pressure.

Recent work by Ebert and Gouy has shown that displacements occur with variations in the density of the vapour producing the light.

In view of these facts the author was led to experiment with spark discharges in liquids which were known to produce very high tensions, as it was impracticable to actually increase the pressure to the extent which would be necessary to give displacements as large as those found in the spectrum of Nova Aurigæ.

The spectrum obtained was 50 mm. in length from λ 4800 to λ 4600, so that considerable accuracy was possible. Photographs of the spectra of iron, nickel, platinum, copper, tin, zinc, cadmium, lead and silver in water were obtained; and comparisons with the spark taken as usual in air, showing that many of the bright lines suffered a considerable displacement towards the *red* under the new conditions. No difference could be detected in the behaviour of water and alcohol. As found by Humphrey and Mohler (Astr. Phys. Jour. 3. p. 135, 1896), the displacements are greater in the spectra of cadmium, zinc and tin, than in the case of iron and platinum.

In addition several sets of double lines appear. These facts and the laboratory experiment showing that the lines of hydrogen from a vacuum tube broaden as the pressure is increased would indicate a possible bearing on the constitution of new stars.

C. P. B.

1650. *Oxygen in Stellar Atmospheres.* **D. Gill.** (Roy. Soc. Proc. 65. pp. 196–206, July, 1899.)—The possibility of certain lines in the spectra of β Scorpii, β Canis Majoris, β Centauri, and β Crucis being due to oxygen was first suggested by F. McClean in 1897, from the evidence afforded by photographs he obtained with his prismatic camera. Since that time he has presented to the Cape Observatory a complete astrophysical equipment, including a 24-inch photographic refractor with objective prism and a powerful slit spectroscope. The present paper is the result of the first series of investigations made with the new instrument. After describing in detail the slit spectroscope, which weighs 400 lb., the author gives some explanation of the methods of interpolation for reduction of the plates, followed by tables of the measured lines in the spectrum of β Crucis, showing the probable coincidences with oxygen. The region of spectrum investigated extends from λ 4187·99 – λ 4563·99, the length of which on the plate is 70·367 mm. Photographs of the spectra of β Crucis and ε Canis Majoris are sent with the article. C. P. B.

LIGHT.

1651. *Characteristics of Crystals.* **C. Leiss.** (Berlin Akad. Sitzber. 3. pp. 42–47, 1899.)—A description is given of a method for obtaining photographic pictures of the section curves of the wave surfaces of crystals. J. J. S.

1652. *Optical Constants of a Crystal.* **C. Viola.** (Roma R. Accad. Lincei Atti, 8. pp. 276–281, 1899.)—Method described whereby, taking directions of plane of polarisation into account, the three indices α, β and γ, the three angles A, B and C, and the angle of the optic axes can be ascertained from any one section of a crystal taken at random. A. D.

1653. *Water Optically Uniform.* **A. Battelli** and **M. Pandolfi.** (N. Cimento, 9. pp. 321–326, 1899.)—Water, quite pure, is not illuminated by a beam of light, and water can be rendered non-illuminable by distilling it in vacuo or by causing the production of a gelatinous precipitate in it. Pure ethylic and amylic alcohol are not illuminated. Air dissolved in water does not appear to be among the causes which render it capable of shining in the track of a beam of light. A. D.

1654. *Reflection at Mercury Surfaces.* **H. Wallbott.** (Wied. Annalen, 68. 3. pp. 471–495, July, 1899).—When mercury is covered with freshly split mica, pure collodium, or well-dried gelatine, only a very slight discrepancy remains between the observed change of phase in the reflected light and its theoretical value. For mica, the following phase accelerations are obtained for the four chief Fraunhofer lines :—

	C	D	E	F
λ	656	589	527	486
ϕ	0·417	0·413	0·405	0·395

The metallo-optical theory for the change of phase at the surface of thick layers of mercury may therefore be regarded as confirmed. The deviations from the theoretical value observed when the covering substance is not quite pure are due to the formation of foreign surface films between the mercury and the cover. As the purity of the covers is gradually increased, the deviations approach vanishing point. The disturbing films produce a greater dispersion of the phase retardations, the latter being increased in the red and reduced in the violet. E. E. F.

1655. *Transmission of Light through an Atmosphere containing Small Particles in Suspension.* **Rayleigh.** (Phil. Mag. 47. pp. 375–384, 1899.)—A mathematical investigation into the attenuation undergone by the primary light on its passage through a medium containing small particles, as dependent upon the number and size of the particles. Regarding the interesting connected question whether the light from the sky can be explained by diffraction from the molecules of air themselves, or whether it is necessary to appeal to suspended particles composed of foreign matter, solid or liquid, the author concludes that even in the absence of foreign particles, the light scattered from the molecules of air would suffice to give us a blue sky, not so very much darker than that actually enjoyed. J. J. S.

1656. *Aberration in Astronomical Telescopes.* **H. Harting.** (Zeitschr. Instrumentenk. 19. pp. 138–143, 1899.)—The author here investigates whether it is possible by suitably choosing the glasses in the two lenses of an astronomical telescope objective, so to arrange the two focal surfaces that they shall be symmetrical with respect to the plane perpendicular to the axis through the principal focus.

He starts with Airy's equations for the curvature of these surfaces where they cut the axis—

$$\gamma_s = 1 + \Sigma\frac{\phi}{n} \text{ and } \gamma_t = 3 + \Sigma\frac{\phi}{n}$$

where $\varphi = \frac{1}{f}$ (f being measured in terms of the focal length of the objective, it being taken as unity), and n is the refractive index.

The condition for symmetry is $\gamma_s = -\gamma_t = -1$, and the conditions to be satisfied by the lens are therefore—

$$\Sigma\frac{\phi}{n} = -2$$
$$\Sigma\phi = 1$$

and the condition for achromatism—

$$\Sigma\frac{\phi}{\nu} = 0$$

where ν is the reciprocal of the dispersive power.

Letting $\lambda = \frac{\nu_1 - \nu_2}{\nu_1}$ the author uses n_1, n_2, and λ as his three variables, and taking values of $1/\lambda = 30$, 12, 6, 4, 3, and 2, he calculates for each of these the values of $\Sigma\frac{\phi}{n}$ corresponding to the thirty-six different combinations obtained by giving six

different values (between 1·50 and 1·65) to n_1 and n_2. There are thus six tables each corresponding to one value of $1/\lambda$, and in each table are six columns of six numbers each. The author has marked those numbers to which he could find glass to correspond in Messrs. Schott and Gen's catalogue.

None of these values, however, make $\gamma_s = -\gamma_t = -1$. The smallest value of $\Sigma\frac{\phi}{n}$ to which glasses correspond is $-0{\cdot}466$ when $1/\lambda = 30$, while the value of $\Sigma\frac{\phi}{n}$ in an ordinary flint-crown combination is $+0{\cdot}762$ when $1/\lambda = 3$. High values of $1/\lambda$ give, however, very low values of $\nu_1 - \nu_2$ (from 0·67 to 2·33 for $1/\lambda = 30$), but even in objectives which require only a small aperture (*e.g.*, those used to photograph the sun), this ν difference must not be less than about eight or ten, so a further limitation is added to the possible flattening of the field. It is, therefore, only possible to make a very slight improvement in the flatness of the field in an astronomical telescope by specially choosing the kinds of glass for the lenses; and this advantage only accrues in the case of projection or of photography, as, immediately an eyepiece is introduced, the aberration in it makes the improvement entirely nugatory. J. B. H.

1657. *Large Speculum.* **P. Gautier.** (Comptes Rendus, 128. pp. 1373–1375, June 5, 1899.)—A description of the manufacture and tests of the speculum referred to in Abstract No. 1131 (1899). C. P. B.

1658. *Oscillating Focometer.* **C. Dévé.** (Comptes Rendus, 128. pp. 1561–1564, June 26, 1899.)—This instrument serves to measure the curvatures, focal lengths, and aberrations of optical surfaces. The optical system producing the image observed is so arranged that it can oscillate about an axis near the image. If the image is observed with the aid of an eyepiece and cross-wires, it follows the oscillations of the apparatus unless it is exactly on the axis of oscillation. If the image passes above or below the axis, its oscillation changes in sense with regard to the oscillation of the apparatus. It is therefore easy to find at once in what sense the image must be displaced to bring it to the level of the axis. When the image appears fixed, the distance of the axis from the optical surface is measured. The precision obtained is much greater than that obtained by the ordinary methods, as may be shown by adjusting the image until no parallax can be detected. There is then, as a rule, some slight residual motion on rotating the apparatus. Only a very small portion of the optical surface need be used at a time, and thus the curvatures of the different portions of the same surface may be compared.

E. E. F.

1659. *Self-Correcting Photometer.* **B. Speed.** (Elect. World and Engineer, 33. p. 873, June 24, 1899.)—A slide rule scale is so applied to a standard glow lamp photometer that corrections for fractional candle-power in the standard can be read off rapidly. M. O'G.

1660. *Photometer.* **J. Hartmann.** (Zeitschr. Instrumentenk. 19. pp. 97–103, 1899.)—This instrument is designed to compare the relative brilliancies of, say, different parts of the moon's surface or of the surfaces of comets, or generally to compare the brilliancies of any two surfaces. The method is a photographic one, the instrument being used to compare the depth of tint at any point on the photographic plate with that on a standard plate; the point on the standard plate which has the same depth of tint being noted. The standard plate has on it a band, the tint of which gradually deepens from one end towards the other, and is provided with a scale along the band. This scale could be graduated by experiment in candle-power corresponding to one definite time of exposure.

The photometer is of the Lummer-Brodhun type, a small ellipse being silvered on the hypotenuse of one of the two prisms before the two are put together. In order to work on very small portions of the plates, microscopic objectives are introduced in the two beams. These form magnified images of the films at the prisms and these images are then examined through an eyepiece. Arrangements are provided for illuminating equally the two plates under comparison. J. B. H.

1661. *Actino Photometer.* **C. Henry.** (Comptes Rendus, 128. pp. 941–943, 1899.)—A good photographic actinometer should measure all the radiations which reduce silver gelatino-bromide, and its indications should strictly correspond with the behaviour of the sensitive plate. These conditions are well fulfilled by the author's phosphorescent zinc sulphide. The most remarkable analogy exhibited is that between halation and the reversing effect of very strong exposures on the luminosity of the sulphide. The author has constructed an actinometer consisting of a series of semi-translucent and semi-phosphorescent screens; after exposure to the source the screen is placed at the end of a tube, and its luminosity compared with that of a screen of ground glass illuminated by a standard candle. Knowing the rate at which the sulphide loses its luminosity, it is easy to determine its original luminosity, acquired under the influence of a source. Measurements with this actinometer show that a solution of alum transmits more actinic rays than a solution of carbon bisulphide. If the intensity of illumination of the two screens of a Foucault photometer is equalised, and a saturated sulphide screen is placed before each, and behind a bichromate vessel, a very rapid means

is obtained for determining the relative value of two sources of light by differences of extinction. E. E. F.

1662. *Amyl Acetate Standard Lamp.* **W. M. Stine.** (Amer. Electn. 11. pp. 208–210, 1899.)—This paper gives a full description of the Hefner-Alteneck standard lamp, and the precautions to be taken in its use. The most important of them is to have the flame at exactly its proper height of 40 mm., as the rate at which the illuminating power increases is 2·5 per cent. for every millimeter above 40, and 3 per cent. decrease for every millimeter below 40. Another correction that is necessary for accuracy is that due to humidity of the air, as a possible error of 8·5 per cent. may exist due to this cause. E. C. R.

1663. *Colour-Weakness and Colour-Blindness.* **E. W. Scripture.** (Science, 9. pp. 771–774, June 2, 1899.)—The author condemns the ordinary wool and card tests for colour-blindness, and emphasises the importance of being able to name the colour. The following cases are given as examples: 1. A person whose eyes were abnormally acute for differences in colour, who could match wools at any distance, but yet who had only two fundamental sensations instead of three. 2. Persons who possess perfect colour vision for near objects or bright objects, but who are practically colour-blind for weakly illuminated or distant objects. Such persons will pass the wool test when performed near at hand. These persons possess the three fundamental colour sensations, but have one of them weaker than the normal.

The author has invented a "colour sight tester" of a different kind. It consists of two concentric discs, one fixed to a handle and having three circular windows in it, one containing ground glass, the second lightly smoked glass, and the third thickly smoked glass. The second disc can rotate on its axis, and has twelve coloured glass windows in it, any one of which can be made to appear behind any one of the three grey windows in the other disc. The colours are mostly greens, greys, and reds, and the appearances as seen through the three different windows give direct simultaneous comparisons of reds, greens, and greys of different shades. J. B. H.

1664. *Diffraction Colour-Photographs.* **R. W. Wood.** (Phil. Mag. 47. pp. 368 372, 1899.)—If a diffraction-grating of moderate dispersion and a lens be placed in the path of a beam of light coming from a linear source, and the eye be placed in any one of the spectra formed to the right and left of the central image, the entire surface of the grating will appear illuminated with light of

a colour depending on the part of the spectrum in which the eye is placed. If one part of the grating has a different spacing from the rest, the spectrum formed by this part will be displaced relatively to the first, and if the eye be placed in the overlapping part of the two spectra, the corresponding portions of the grating will appear illuminated in different colours. This principle has been made use of by the author in the development of a new method for producing photographs in natural colour. The use of pigments and coloured screens is eliminated in the finished picture, the photograph being simply a diffraction-grating of variable spacing, the width between the lines in the different parts of the picture being such as to cause them to appear illuminated in their proper colours when viewed as described. Details of the manipulation are given. The apparatus for viewing the pictures consists of a cheap double-convex lens mounted on a small frame with a perforated screen for bringing the eye into the right position. The author considers that by the use of a suitable photographic plate to be exposed in succession in the camera, under red, green, and blue screens, on the surfaces of which suitable diffraction-gratings have been photographed, it will be possible to obtain the colour-photograph directly. J. J. S.

1665. *Equations of a Plane Electromagnetic Wave.* **E. B. Rosa.** (Phys. Rev. 8. pp. 282–296, 1899.)—The author shows briefly the formation of the differential equations by which light as an electromagnetic phenomenon is characterised. The student, he says, is apt to wonder how so much information can be extracted from differential equations, although perhaps a differential equation is the necessary form in which the result of observations is expressed. Having explained the derivation of the ordinary equations, he makes the assumption that we have a wave of electric force travelling along the axis of x, the force varying as the sine of an angle. From this assumption he explains by the aid of diagrams from general considerations the properties of such a wave. S. H. B.

1666. *Diffraction Fringes Applied to Micrometric Observations.* **L. N. G. Filon.** (Phil. Mag. 47. pp. 441–461, 1899.)—This paper is a criticism and extension of a previous paper by A. A. Michelson, "On the Application of Interference Methods to Astronomical Observations." The author first deduces a general expression for the intensity of the illumination at any point of the diffraction pattern formed by a lens on a screen when light from a point source is transmitted through two equal and parallel slits in an opaque membrane, each of a definite length and width. The case of two point sources is then considered, and the modifications produced by the overlapping of their diffraction patterns are noticed.

It may be observed that, when two diffraction patterns arising from two distinct sources overlap, it is not unfrequently assumed that the intensity at any point of the overlapping region is equal to the sum of the intensities which each source separately produces at that point. This is true in a particular case, viz., when the phases of the two vibrations produced by the two sources at the point in question differ by 90°. Under all other circumstances the phase difference δ must be taken into account, and the resultant intensity is not I_1+I_2, but $I_1+I_2+2\sqrt{I_1I_2}\cos\delta$.

The theory is next applied to the case of an extended source, and a general expression is obtained for the intensity at any point of the diffraction pattern. If $2h$ be the length of either slit, the three cases which present themselves and which are considered in detail are :—

1. When the angular dimensions of the source are large compared with λ/h.

2. When the angular dimensions of the source are small compared with λ/h.

3. When the angular dimensions of the source are neither large nor small compared with λ/h.

The final conclusions arrived at are that :—

1. It is possible by the observation of Michelson's interference-fringes to separate a double point source, or detect breadth and ellipticity in a slightly extended source.

2. But the distance between the two points, or the dimensions of the extended source, must be within certain limits, depending on the length and breadth of the slits.

3. The dimensions of the slits also considerably affect the general theory, the formula obtained not being identical with Michelson's. The law of appearance and disappearance of the fringes depends very largely on the distance between the points or the dimensions of the extended source. T. P.

1667. *Velocity of Light in a Magnetic Field.* **E. W. Morley, H. T. Eddy,** and **D. C. Miller.** (Amer. Assoc. Proc. 47. pp. 123–124, 1898.)—As the result of their experiments the authors report that when light corresponding to the solar D line passes through 120 cm. of carbon bisulphide in a magnetic field sufficient to produce rotation of the plane of polarisation by half a circumference, there is no such change of velocity as one part in sixty million, probably not one part in one hundred million. J. J. S.

1668. *Vibrations of Charged Ions in a Magnetic Field.* **H. A. Lorentz.** (Archives Néerlandaises, 2. 5. pp. 412–434, 1899.)—This is a mathematical paper by which on certain hypotheses the presence of a number of rays is predicted and their frequencies

and intensities calculated. On *observing perpendicularly* to the lines of force, the following rays are accounted for: A. Rays whose *vibrations* are *parallel* to the lines of force—a median ray and two outside rays. B. Rays whose *vibrations* are *perpendicular* to the lines of force—six rays, being two of each of three classes. On *observing along* the lines of force the same rays are obtained as in case B, and of the same relative intensities, but they are now *circularly polarised*. E. H. B.

1669. *Zeeman Effect and Theory of Lorentz.* **H. Poincaré.** (Écl. Electr. 19. pp. 5–15, 1899.)—This is a general exposition of the theoretical explanation advanced by Lorentz to account for the radiation phenomena in a magnetic field—known as the Zeeman effect. When it was found by experiment that different spectral lines behaved in different ways in the magnetic field, some being resolved into quartets, sextets, octets, or other complex forms, it became evident that the simple theory, which indicated tripling only for all the spectral lines, required modification and extension. This extension was introduced by Lorentz in the shape of an hypothesis concerning the ions. The simple theory supposed the ions to be simple electrified particles, and the further extension assumes them to be complex dynamical systems. This new supposition leads to equations of a more complex character, which appear to explain some at least of the more complex results obtained by experiment. T. P.

1670. *Effect of Medium upon Wave Form of Light.* **W. Voigt.** (Wied. Annalen, 68. 3. pp. 598–603, July, 1899.)—In a medium in which the propagation of plane waves is governed by the equation

$$\frac{\partial^2 u}{\partial t^2} = a^2 \frac{\partial^2 u}{\partial z^2}$$

all vibrations are propagated with unaltered phase. But that equation is the only one possessing that property, and it only applies to a vacuum, or to the propagation of purely periodic vibrations. The author shows that ordinary light does not by any means consist of such vibrations, and that monochromatic light, propagated through a dispersing or absorbing medium, must, after emergence, be accompanied to a slight extent by light of all other wave-lengths. E. E. F.

1671. *Broadening and Reversal of Spectrum Lines.* **W. Voigt.** (Wied. Annalen, 68. 3. pp. 604–606, July, 1899.)—The broadening of the D lines observed by Wanner (see 1899

Abstract No. 1347) is partly explained by the reasoning in the preceding paper, and partly by the effect of the simultaneous action of independent volume elements of the flame, dealt with by the author in a former paper. Reflection at the surface of an absorbing body must produce the same effect as absorption by the same body, since the reflected wave is connected with the refracted wave by the terminal conditions. E. E. F.

1672. *Sellmeier's Theory.* **Kelvin.** (Phil. Mag. 47. pp. 302–308, 1899. Read before the Royal Society of Edinburgh on February 6, 1899.)—A discussion of the application of Sellmeier's dynamical theory to the dark lines D_1, D_2 produced by sodium-vapour. A definite mechanical representation of Sellmeier's theory is given, and Becquerel's recent experiments showing anomalous dispersion by prisms of sodium-vapour are referred to. In Becquerel's photographs the characteristic nullity of absorption and finite breadth of dark lines, originally shown in Sellmeier's formula of 1872, are exhibited for the first time. The author gives various graphical illustrations of the results of Sellmeier's theory based on the experimental case of sodium-vapour.

J. J. S.

1673. *Determination of Reference Lines in Spectra.* **M. Hamy.** (Comptes Rendus, 128. pp. 1380–1382, June 5, 1899.) —Until a few years ago physicists were dependent on diffraction gratings for the absolute determination of the wave-lengths of the lines in discontinuous spectra, but the work of A. A. Michelson on luminous sources of sufficient simplicity to give interference under very great retardation has rendered possible a much more critical determination of these important constants.

The author proceeds to describe the method he is following for measuring the wave-lengths of standard lines throughout the spectrum by the use of interference fringes. To enable him to do this he has designed what he calls a "simplifier" (see Comptes Rendus, 125, p. 1092, 1897), with which he can suppress one or more members of a doublet or a triplet without appreciably reducing the intensity of the remaining light. He has used interference fringes of two types:—

1. Newton's rings from light almost parallel at normal incidence. These are obtained by passing the light through a semicircle of small diameter fixed at the focus of a collinator, the lens of which has its outer face thinly silvered, this being placed near to a small plane silvered mirror, which reflects the image of the semicircle back again to the focus of the lens. The fringes thus produced, he says, are very sharp, and are visible with as great a retardation as 10 cm. The measures of wave-length are independent of the diameter of the aperture and the focus of the lens.

2. The fringes localised at the focus of a plano-convex lens, the plane surface of which is half-silvered and placed parallel to a plane mirror totally silvered.

The source of light preferred is that given by vacuum tubes excited by an induction coil (using 3–4 amperes at 10 volts) both with and without a condenser in parallel on the secondary circuit.

C. P. B.

1674. *Dispersion : Luminous and Electric.* **L. Barbillion.** (Écl. Electr. 19. pp. 246–252, 1899.)—The author discusses the various theories of optical dispersion put forward by Cauchy, Kelvin, Helmholtz, and others, and seeks a single expression which shall embrace, in accord with experiments, both luminous and electric waves. E. H. B.

1675. *Absorption Spectrum of Benzene.* **W. N. Hartley** and **J. J. Dobbie.** (Journ. Chem. Soc. 73. pp. 695–697, 1898.)—A description of the spectrum of benzene, the measurements having been taken from solutions of benzene in alcohol. Strong absorption bands to the number of six were observed. The absorption bands are sharpest where the rays are of shorter wave-length, and are gradually weakened in the opposite direction, as if they were groups of lines closer together and stronger on the side where the rays are of smallest wave-length. J. J. S.

1676. *Simple Apparatus for Spectroscopic Photography.* **J. H. White.** (Scientific American, 80. p. 43, 1899.)—An account of results obtained with a small pocket spectroscope and camera. With fifteen seconds exposure a picture of the solar spectrum three inches long with abundance of lines was obtained. J. J. S.

1677. *Spectroscope with Variable Scale.* **A. de Gramont.** (Comptes Rendus, 128. pp. 1564–1568, June 26, 1899).—To reduce a spectrum observed in an ordinary spectroscope to any desired micrometric scale, the author constructs a spectroscope in which the micrometer is mounted in an extra collimator, and its image is reflected into the telescope by a face of the prism. An arrangement of two lenses in the extra tube permits the observer to enlarge or reduce the micrometer scale. By rotating the prism out of the position of minimum deviation, the author is also enabled to change the dispersion of the prism in any given region. These two adjustments facilitate the mapping of an unknown spectrum in terms of a known one. E. E. F.

1678. *Echelon Spectroscope.* **A. A. Michelson.** (Journ. de Physique, 8. pp. 305–314, June, 1899.)—The chief portion of the paper consists of a detailed description of the principle and theory of the echelon, which has already been previously published (see 1898, Abstract No. 1118). The mathematical portion of the theory is, however, somewhat more complete in the present article. Following this the author describes experiments he has been making in the endeavour to overcome the difficulties involved in using a "reflection echelon," the principle of which is that the several plates are separated by minutely different thicknesses of air, the effect of which on the resolution of the spectra is *six* times as great when the instrument is used by reflection as when it is used by transmission.

C. P. B.

1679. *Charge Carried by Röntgen Ions.* **J. J. Thomson.** (Phil. Mag. 46. pp. 528–545, 1898.)—In a gas exposed to Röntgen rays and acted upon by a known electromotive force, measurement of the current passing gives the value of nev, where n is the number of ions in unit volume of the gas, e is the charge on an ion, and v is the mean velocity of the positive and negative ions under the electromotive force to which they are exposed. The object is to find e. Rutherford (Phil. Mag. 44. p. 422, 1897) has given values of v: it remains to find n. The method used depends on the discovery of C. T. R. Wilson (Phil. Trans. A. 1898, p. 265) that when Röntgen rays pass through dust-free air a cloud is produced by an adiabatic expansion which is incapable of producing cloudy condensation when the gas is not exposed to these rays. The ions caused by the Röntgen rays seem to act as nuclei, round which the water condenses. If we knew the size of the drop and the mass of water deposited we would know the number of drops and therefore the value of n. Measurement of the size of the drops by optical means proved inapplicable, and the method finally adopted was to apply the formula for v, the rate at which the cloud sank; $v = 2ga^2/9\mu$, where a is the radius of the drop, μ the coefficient of viscosity of the gas through which the drops fall, and g the value of gravity. It was established that the ions do act as nuclei: if the ions be removed by exposing the expanding air to a strong electric field, no cloud is formed. But the ions are not all carried down by the cloud; some remain, modified and apparently heavier or more complex, which induce secondary cloud condensation when the expansion is repeated. With sufficiently weak Röntgen rays this complication is absent. The number of ions brought down by a larger expansion (within the limits of 1·25 and 1·40 times the original volume of the gas) is slightly greater than with a smaller one: and it seems probable that positive and negative ions have unequal powers of acting as nuclei, a circumstance which would account for the charging of clouds and the production of atmospheric electric fields, the

work required for the production of the field being done by gravity as the charged cloud sinks. The amount of water deposited was computed from thermodynamic and hygrometric data: and the volume and corresponding mass of each droplet were computed from the radius as shown by the rate of fall of the cloud: whence n is of the order 4×10^4 in unexpanded gas. This being ascertained, e is then found to be about $6{\cdot}3 \times 10^{-10}$. Correction for a certain number of nuclei, present in any case and not produced by Röntgen rays, brings this to about $7{\cdot}4 \times 10^{-10}$: and the mean of a series of experiments gives the value $7{\cdot}3 \times 10^{-10}$. But a further correction has to be made for escape of current along the dampish sides of the vessel; this is found to bring the mean result down to $e = 6{\cdot}5 \times 10^{-10}$, for air. For hydrogen, the charge on the ions seems, on the whole, to be the same as in air. In the preceding it is assumed that the potential gradient is constant between the plates, and that all the ions produced are brought down by the cloud; with the weak rays experimented on, the result would be much the same as regards the former of these, but would have to be diminished if any ions were left behind. In any case, electrolytic data give $Ne = 129 \times 10^8$ where N is the number of molecules in 1 cub. cm., and e the charge of each molecule of hydrogen (in E.-S. units); the value $e = 6{\cdot}5 \times 10^{-10}$ would make $N = 20 \times 10^{18}$, whereas under the kinetic theory of gases, experiments on the viscosity of gases give the value $N = 21 \times 10^{18}$. The value given is therefore consistent with the charge carried by the ion produced by Röntgen rays being equal to or of the same order as the charge carried by the hydrogen ion in electrolysis. A. D.

1680. *Triboluminescence.* **W. J. Pope.** (Nature, 59. pp. 618–619, 1899.)—A note on the emission of light not due to rise of temperature which occurs on crushing fresh crystals (from solution in acetone) of commercial saccharin (ortho-benzoic-sulphinide); and also some references to the literature of the subject. A. D.

1681. *Colson-Russell Photographic Effect.* **J. H. Vincent.** (Chem. News, 79. pp. 302–303, June, 1899.)—The paper shows that certain bodies such as indiarubber and camphor, which have been proved by Russell to be quite inactive on a photographic plate in their ordinary condition, become highly active when treated with small quantities of ozone. If a stream of ozonised air be passed through a box containing a sensitive plate below a sheet of indiarubber, the plate will, after five minutes' exposure, give a dark negative image after development, of any opaque body placed between it and the indiarubber. The indiarubber remains active for some days after once ozonising, and, if washed

with water, this becomes exceedingly active. A plate, after being subjected to the influence of the ozonised rubber, will before development produce a transfer image on a second plate put in contact with it. The opacity or transparency of different bodies is found to be the same for the active agent from ozonised rubber as for that in the Russell effect. The author attributes the effect to the formation of hydrogen peroxide, as does Russell for his photographs. The water used for washing ozonised rubber gave the tests for hydrogen peroxide. G. H. Ba.

1682. *New Radio-Active Substance.* **E. de Haën.** (Wied. Annalen, 68. 4. p. 902, August, 1899.)—By extraction from a large quantity of uranium ore, the author has obtained substances which possess the properties ascribed by M. and Madame Curie to "radium" in an extraordinary degree. Two preparations have been made. Preparation A exhibits the properties of Becquerel rays. It excites fluorescence in a barium platinocyanide screen even across opaque substances, affects the photographic plate, makes air electrically conducting, and has an additional property not hitherto described, that of being itself strongly luminous. Preparation B possesses in general the same properties as preparation A, but the excitement of the screen is more intense, whereas the self-luminosity is feebler. In both cases the rays which produce fluorescence penetrate bodies like black cardboard more readily than they penetrate glass. Both preparations must be carefully preserved from moisture, especially the first preparation, which loses its own luminosity in a few hours when exposed to the moisture of the atmosphere. Once the luminosity is lost it is difficult to restore it. The only expedient which succeeds as a rule is that of melting the substance in the oxy-hydrogen blowpipe. E. E. F.

1683. *Luminosity of the Rare Earths.* **A. A. C. Swinton.** (Roy. Soc. Proc. 65. pp. 115–119, June, 1899.)—The Welsbach incandescent gas mantle contains 99 per cent. thoria and 1 per cent. ceria. This gives eleven times as much light as pure thoria. Acting upon the earths with kathode rays in a vacuum tube, they were brought up to incandescence. The Welsbach mantle mixture gave a little more, but very little more, than pure thoria. Where pure thoria gives a bright light, ceria gives practically none. Kathode rays appeared to reduce the oxides partly to the metallic state. A. D.

HEAT.

1684. *Thermal Conductivity of Ebonite and Glass.* **A. Dina.** (N. Cimento, 9. pp. 461–465, June, 1899.)—Observing that when strips of tinfoil were placed on glass or ebonite and heated, their fusion was retarded 40 and 10 per cent. respectively, owing to thermal conduction, the author devised a method of determining thermal conductivities of bad conductors in which the substance is first heated and then one of its surfaces suddenly cooled. The outward flow of heat depends upon the conductivity; and the amount of heat it possesses after a given interval can be measured with a calorimeter. The author shows how to calculate the conductivity from the calorimeter readings. He finds that of glass to be 0·152, and that of ebonite 0·023.

E. E. F.

1685. *Thermal Conductivity of Ice.* **P. Straneo.** (N. Cimento, 7. pp. 333–340, 1898.)—The author considers the methods hitherto employed to determine the conductivity of ice unsatisfactory, namely, those of Mitchell, De la Rive, Forbes, and F. Neumann. He first describes experiments made with cubes of ice of two different kinds. It appeared from these that ice often presents different phenomena according to direction, whether vertical or horizontal, arising from the position of the water during congelation. He then describes a second series of experiments made with long cylinders of ice, one cut with vertical the other with horizontal axis, in order to determine the different rates of conduction in the two cases. The coefficient of conductivity derived from the first series is 0·31. A small difference is found to arise from the direction in the second series. (See also 1898, Abstract No. 388.) S. H. B.

1686. *Temperature Changes of Glass and Thermometer Zero Points.* **L. Marchis.** (Zeitschr. Phys. Chem. 29. pp. 1–26, 1899.)—This is a German translation of the author's abstract (Mem. Soc. Scien. Bordeaux (5) 4) of a longer thesis, and much resembles a paper already abstracted (see 1899, Abstract No. 554). The position taken up is that the volume of a thermometer (or other piece of glass) kept at an absolutely constant temperature will itself remain absolutely constant: that any change in its volume at this temperature is due to an oscillation of its temperature: that if the thermometer be made to continually vary between two given temperatures its volume at each temperature will gradually alter to a limiting value which depends on the other: that this progress to a limit at either temperature is quickened by an oscillation of the temperature whenever, during this progress, the

other given temperature is reached. The question is thus one of pure hysteresis, and the memoir is consequently based on Duhem's work (see 1898, Abstract No. 1228). Experimental results are cited in support of the theory. A second memoir will detail the work that has been done respecting the displacement of the zero-point, which is in ordinary cases ascribed to the unavoidable variations of temperature in a laboratory. (See also 1899, Abstract 1490.) R. E. B.

1687. *Constants of Normal Heptane.* **S. Young.** (Journ. Chem. Soc. 73. pp. 675–681, 1898.)—The vapour pressures at low and high temperatures, the specific volumes and critical constants of normal heptane are given in a set of tables. This substance, whose boiling-point is 98·43, and sp. gr. at 0° is 0·70048, has the following critical constants: temperature, 266·9°; pressure, 2041·5 cm.; density, 0·2344; volume of a gramme, 4·266 cc.; molecular volume, 425·7. The critical densities of isopentane, normal pentane, normal hexane, and normal heptane, are nearly identical. J. J. S.

1688. *Thermal Properties of Normal Pentane.* **J. Rose-Innes** and **S. Young.** (Phil. Mag. 47. pp. 353–367, and 48. pp. 213–214, August, 1899.)—Particulars of the data obtained in four series of determinations are given. These include (1) volumes of liquid to critical point; volumes above critical temperature to 280°; (2) volumes of unsaturated vapour from 140° to critical point; volumes above critical point to 280°; (3) volumes of vapour at and above 80°; (4) volumes of vapour at and above 40°. From the data deduced from the simultaneous observations of pressure and volume at various temperatures, the values of b and a in the equation $p=b\,\mathrm{T}-a$ were obtained graphically. As in the case of previous results obtained for isopentane the deviations are very small at the largest and smallest volumes and about the critical volume, but are larger at intermediate volumes. The relation $p=b\,\mathrm{T}-a$ at constant volume is a very close approximation to the truth. As with isopentane the molecular pressure a appears not to follow a continuous law, but passes abruptly from one law to another somewhere about vol. 3·4.

In the second paper the authors discuss the relations between the volume, temperature, and pressure of normal pentane. A comparison of the behaviour of isopentane and normal pentane is made. It is concluded that the difference of pressure between two isomeric substances at the same temperature and volume involves the same power of the density as the first deviation from Boyle's law, *i.e.*, the second power. J. J. S.

1689. *Thermal Properties of Isopentane.* **S. Young** (Zeitschr. Phys. Chem. 29. pp. 193–241, June, 1899.)—Three specimens of isopentane were very carefully purified, and measurements taken to trace out the characteristic equation $f(p, v, T) = 0$. The measurements include the boiling-point under atmospheric pressure; the density at 0° and atmospheric temperature; the critical temperature and pressure; the vapour pressure from $-31°$ to $+28°$ by the dynamic method, and at higher temperatures by the pressure apparatus already described by the author; the specific volume of saturated vapour and liquid by the same apparatus and by heating a known mass of the substance in a sealed graduated tube (Trans. Ch. Soc. 59, 37. 63, 1201). The most difficult correction was for the varying pressure of mercury vapour at high temperatures, saturation not being reached during the course of an ordinary experiment. Full details are given of how this difficulty was met. The critical volume was found by the method of Cailletet and Mathias. $T_c = 187°{\cdot}8$ $p_c = 25020$ mm. $V_c = 4{\cdot}266$ cc.

The relation, $p = a + bT$ (v const.), is nearly verified, but the deviations from it cannot be accounted for as experimental errors. The values of a and b are fully tabulated and represented graphically: they show a marked singularity, if not discontinuity, at $v = 3{\cdot}2$ as was the case for ether. Tables are also given comparing isopentane and benzene in corresponding states; the agreement is very close. At the critical point the actual density is 3·73 times the theoretical, which agrees with the substances of the benzene group studied (3·65 to 3·83) and with carbon dioxide (3·62 according to Amagat). The molecules of isopentane are therefore presumably unassociated. R. A. L.

1690. *Thermostat.* **R. Rothe.** (Zeitschr. Instrumentenk. 19. pp. 143–146, 1899.)—The thermostat here described is the one used in the Reichsanstalt for comparing thermometers at temperatures up to 500° C. The heating is done electrically, a coil being placed in the oil or other fluid (oil up to 300°, air up to 500°) forming the bath containing the thermometers. For description of the stirring arrangement, the protection against loss of heat, and the other details of the apparatus reference must be made to the paper. J. B. H.

1691. *Biological Thermodynamics.* **A. Chauveau.** (Comptes Rendus, 129. pp. 249–258, July 31, 1899.)—The author has conducted experiments on the production of work and heat in muscular action, in specially constructed apparatus of large size. Three series of experiments are recorded in which (i.) a man works a friction wheel inside a calorimeter, and the entire pro-

duction of heat and work is absorbed by the calorimeter; (ii.) the man remains inside the calorimeter, but the friction wheel is outside. In these two series the muscular action is that of walking upstairs. (iii.) The man is again inside the calorimeter, but the wheel is driven from outside in the opposite sense, so that the action is that of walking downstairs. Further, the evolution of water vapour and carbon dioxide was measured in order to estimate independently the liberation of chemical energy. In series (i.) the production of heat was 263 cals. per hour: in series (ii.) 199 cals., while the work "exported" from the calorimeter was estimated at 68 cals. This verifies, within the limit of experimental error, the application of the first law of thermodynamics to muscular action. In series (iii.) the production of heat was 170 cals. whilst the measurement of CO_2 exhaled show 257 cals. when the subject was doing positive work in agreement with series (i.) and 126 during negative work. It may therefore be concluded that when work is absorbed by the body the equivalent in heat is generated in it, besides the heat due to combustion of the tissues, although the proof of this point is not quantitatively exact. Electric heating was employed to calibrate the calorimeter.

R. A. L.

1692. *Heat-stuff, Energy and Entropy.* **O. Wiedeburg.** (Zeitschr. Phys. Chem. 29. pp. 27–50, 1899.)—As it is difficult to frame an exact idea of what entropy is, and as entropy does not conform to the conservation-law which applies to other quantities classed as "capacity-factors" in energetics, the author reverts to the idea of a heat-stuff, to which, he contends, the energy-idea is not antagonistic and by which the entropy-relations can be explained. (See also 1899, Abstract No. 62.) R. E. B.

1693. *Limits of the Solid State.* **G. Tammann.** (Wied. Annalen, 68. 3. pp. 553–583, July, and 68. 4. pp. 629–657, August, 1899.)—Experiments made upon a large number of organic substances show that as long as the heat of fusion is positive, the melting curves are convex towards the axis of pressures, and so are the transformation curves. In a single case, that of ammonium nitrate, the curvature of the transformation curve is in the opposite sense. This is accompanied by an anomaly in the specific heat. It is also evident that at temperatures and pressures where the heat of fusion is nearly or quite zero (acetic acid, diethylamine, water, silver iodide), the difference in the specific volumes of the liquid and the crystals is still considerable.

If the pressure increases and the melting curve ascends to

higher temperatures, the following maximum fusing-points are indicated by extrapolation :—

Naphthalene	261°	and	11,500 kg. per sq. cm.
Carbonic acid... ...	76°	„	13,000 „
Ethylene dibromide ...	178°	„	12,900 „
Calcium chlorhydrate...	86°	„	10,000 „
Hydrocyanic acid ...	81°	„	7,400 „
Dimethyl ethyl carbinol	36·5°	„	4,400 „

In the last substance measurements could be carried close up to the maximum fusing-point.

Triple points, at which two polymorphous crystals were in equilibrium, were observed in carbonic acid, sulphur, and other bodies. Ammonium nitrate showed a triple point with an equilibrium between those crystalline forms at a temperature of 64·1° and a pressure of 930 kg. E. E. F.

1694. *Kinetic Theory of Liquids.* **G. Jäger.** (Wied. Annalen, 68. 3. pp. 615–617, July, 1899.)—The author defends his former paper against the criticism of W. Voigt. He points out that if molecules are assumed to be bodies of definite dimensions, and either perfectly elastic or perfectly hard, it is impossible to assume a diminution of their size a hundredfold on passing from the gaseous to the liquid state. E. E. F.

1695. *Mixture of Gases.* **P. Sacerdote.** (Journ. de Physique, 8. pp. 319–329, 1899.)—A similar paper to that referred to in Abstract No. 253, 1898. R. E. B.

SOUND.

1696. *Measurement of Sound.* **B. F. Sharpe.** (Science, 9. pp. 808–811, June 9, 1899.)—The method adopted was based upon the suggestion of Webster, that the optical arrangement of Michelson's refractometer, combined with an acoustical method employed by Wien (Wied. Ann. 1899, p. 835), might yield a sound-measuring apparatus of great sensitiveness. For this purpose, one totally reflecting mirror of the refractometer was made very small and light, and was mounted upon a thin glass plate, which formed a portion of the walls of a spherical Helmholtz resonator. A pure tone of the same pitch as the resonator causes the bands to vibrate with the same frequency. The fringes were made vertical and then cut down to a narrow horizontal line by means of a slit. This line was viewed with a telescope whose objective was small, and mounted upon the prong of a tuning-fork of the same pitch as the source of sound. It vibrated vertically, and so drew the line out again into a band of vertical fringes, which became inclined to the vertical as soon as the resonator received a sound of the same pitch. The inclination depended upon the intensity of the sound and the difference of phase. To obtain the maximum inclination the prongs of the telescope fork were slightly loaded so as to obtain low beats. Thus the phases of one vibration overtook those of the other very slowly, and consequently the interference bands were obtained sloping first to the right and then after an interval to the left, the changes occurring periodically and following each other as slowly as desired. By means of a suitable eye-piece with divided circle the angle of this slope could be measured, and gave immediately a means of measuring relative intensities. For photographic recording, the telescope with vibrating eyepiece was replaced by a fixed lens system which focussed a narrow band of fringes upon a sensitive film mounted upon a uniformly revolving cylinder in a manner similar to that employed by Raps. A pure, constant, and portable source of sound was obtained by driving a tuning-fork of about the same pitch as the note desired by an electromagnet with a current interrupted by a similar control-fork, electrically driven by the usual method of self interruption. The first fork was fastened vertically upon a heavy iron base, and one of its prongs was connected to a circular thin iron plate, of approximately the same pitch as the fork, by means of a short stiff wire. This plate formed a side of a Helmholtz resonator, constructed to give the note desired, and rigidly supported. A very small vibration of the fork suffices to give a very loud tone, and the intensity may be governed by varying the current driving the source fork.

E. E. F.

1697. *Vibrations of Caoutchouc Strings.* **V. von Lang.** (Wied. Annalen, 68. 2. pp. 335–342, June, 1899.)—If a caoutchouc thread is stretched with both hands and plucked near the ear, it is noticed that after a certain point its pitch is only very slightly altered by further tension. This is intelligible when it is remembered that in caoutchouc there is always a certain interval during which the length of thread is proportional to the tension. By Taylor's formula the pitch is proportional to the square root of the ratio of tension to length. Hence the constancy of the pitch for that interval. The author tests this theory with the aid of bicycle pump tubes, and finds several maxima and minima of pitch. E. E. F.

1698. *Air Waves produced by a Pendulum.* **E. Ketteler.** (Wied. Annalen, 68. 1. pp. 74–91, 1899.)—The author investigates mathematically the action of a pendulum as a generator of air waves, and as a resonator to the same. The pendulum is conceived as a disc vibrating in an infinite tube, the cross-section of which it nearly fills up, and subject to a force varying with its displacement. It is found that air and pendulum always vibrate together, without lag. By conceiving the tube as returning into itself, the case is created of the pendulum resounding to its own vibrations. The investigation has an important bearing upon the theory of the tuning-fork and other acoustic appliances.

E. E. F.

1699. *Acoustic Resonators.* **A. Pochettino.** (Roma R. Accad. Lincei Atti, 8. pp. 260–264, 1899.)—The author investigates the damping coefficient in a resonator as depending upon the shape of its aperture, the addition of flanges, and the distance from the source. He finds that the shape of the aperture has very little influence, provided the size remains constant. As the diameter of the flange increases, the resonance increases for any proper note, and decreases for notes slightly out of tune. The resonance also subsists for a longer time. The same consequences are observed when the distance from the source is increased. E. E. F.

ELECTRICITY.

1700. *Effect of a Solid Conducting Sphere in a Variable Magnetic Field on the Magnetic Induction at a Point Outside.* **C. S. Whitehead.** (Phil. Mag. 48. pp. 165–180, August, 1899.)—We are to suppose an alternating current in a circular circuit whose axis passes through the centre of the conducting sphere. When the radius of the sphere is very great compared with the radius of the circuit, the sphere is in effect an infinite plane sheet. The author obtains expression for R_d the maximum value of the normal component of magnetic induction, and T_d the maximum value of the tangential induction. It appears that when d, the distance of the circuit from the plane, is very small compared with ρ, the distance of the point observed from the axis, R_d is very small compared with T_d. In induction telegraphy, assuming the infinite plane to be represented by sea water, this is exactly what happens. It is inferred that the best effect is obtained by making the receiving circuit vertical. The normal magnetic induction is shown to be much greater for sea water than for iron or copper. The general case when the radius of the sphere is not infinite is investigated. S. H. B.

1701. *Irreversible Radiation Processes.* **M. Planck.** (Berlin Akad. Sitzber. 25. pp. 440–480, 1899.)—This is the fifth and concluding memoir (see 1899, Abstract No. 268, &c.). We are to suppose a vacuum bounded by completely reflecting surfaces, in which exist electromagnetic waves, and one or more resonators or dipols. If f is the moment at time t of a resonator whose oscillation period is ν, Z the intensity of the field resolved in direction of the resonator, then the known equation for f is—

$$\frac{d^2f}{dt^2}+2\sigma\nu\frac{df}{dt}+4\pi^2\nu^2f=\frac{3c^3\sigma}{4\pi^2\nu}Z,$$

in which c is the velocity of light, and σ the damping of the resonator, understood in this case to arise, not in any degree from ohmic resistance, but from the emission of energy by the resonator.

In Part I. the author gives a solution of this equation, from which he shows that, σ being very small, only those oscillations of the medium sensibly affect the resonator, whose period is equal, or nearly equal, to that of the resonator. An expression is then obtained for the energy of the resonator, and for its rate of absorption and emission of energy. The intensity of the exciting oscillation in the field is then calculated as a function of the period or inverse wave-length.

Natural radiation is defined as follows: The energy of the

resonator, denoted by U, contains in its expression certain variables which vary rapidly with the time, *i.e.*, change sensibly during the period of oscillation. It is assumed that in lieu of these variables we may use their mean values over a time very long compared with the oscillation period, and that is defined to be natural radiation.

The fundamental equation of the theory is then given in the form—

$$\frac{dU}{dt} + 2\sigma\nu U = \frac{3c^3\sigma}{16\pi^2\nu} I,$$

where I is that part of the energy of the field which arises from oscillations of the period ν.

In Part II. expressions are given for the energy per unit of volume of the field, and for the intensity of the exciting oscillations, having regard to the direction of polarisation, also, under the same circumstances, for the energy absorbed and emitted by the resonator.

The entropy S of a resonator is defined analogously to Boltzmann's H function as—

$$S = -\frac{U}{a\nu} \log_e \frac{U}{b\nu}$$

where a and b are constants, and e the base of the natural logarithms. The entropy s per unit volume of the field is defined in the same way as the energy, every pencil of rays being assumed to possess and to carry with it, and to communicate entropy, just as it possesses and carries and communicates energy. It is then shown that, given a number of resonators in the field, and any system of polarisation in the medium, the entropy is either constant or increases. The stationary state is reached when the entropy is constant, *i.e.*, maximum, and this state is shown to depend on a single variable θ, namely, $\frac{1}{a\nu} \log \frac{U}{b\nu}$.

In Part III., which relates to thermodynamics, the temperature is defined as $\frac{dQ}{d\theta}$, where θ is the variable above mentioned, and Q a small addition of heat.

Considering the relation between radiation and temperature, Planck obtains the result given by Wien and others, namely—

$$E\lambda = \frac{2c^2b}{\lambda^5} \varepsilon^{-\frac{ac}{\lambda\theta}}$$

expressing the energy of that part of the spectrum which has wavelength λ. S. H. B.

1702. *Dimensions of Electrical Units.* K. Schreber. (Wied. Annalen, 68. 3. pp. 607–614, July, 1899.)—The reduction of the

physical units and measurements to the fundamental units of mass, space, and time has only been fully carried out in mechanics. Measurements connected with sound, light, heat, magnetism, and electricity are still based upon arbitrary units, and the author maintains that their reduction to the fundamental units is an impossibility. The equations of magnetic and electrostatic attraction formulated by Coulomb have, as pointed out some time ago by Rücker, different constants, whose dimensions used to be suppressed, with the result that different dimensions were given to the electromagnetic quantities, according as to whether they were founded upon the electrostatic or the electromagnetic system of units. The discovery of new relations, such as the action of a magnet upon a current, does not solve the difficulty, since it introduces another constant of unknown dimensions. E. E. F.

1703. *Networks of Conductors of Finite Transverse Dimensions.* **J. B. Pomey.** (Écl. Électr. 19. pp. 169–172, 1899.)—A mathematical paper containing an extension of some results of the electrostatic theory of a system of conductors, as developed by Maxwell, to the case of a system of tubular conductors conveying currents. A. H.

1704. *Theories of Atmospheric Electricity.* **Chauveau.** (Paris, Soc. Franc. Phys. Bull. 133. pp. 2–3, June, 1899.)—A very brief *résumé* of the theories advanced. The author suggests that the complex phenomena need not all have the same cause. Peltier's dissipation of negative electricity by water vapour would help to explain the electricity of the lower strata. As regards the positive charges of cirrus clouds, we have the hypotheses of Sohncke and of Brillouin. But we cannot account for the fact, established by balloon observations, that for elevations up to 7,000 m. the electric potential first rises and then assumes a constant value. Attention is drawn to Lenard's hypothesis of a positive electrification of the air by the spray from the ocean waves, to Edlund's unipolar induction, which seems to explain auroral displays, and to Rowland's observation that the mechanical transport of electrified masses generates currents. Further prolonged observations are needed, such as those conducted by Andrée at Spitzbergen in 1882–1883. H. B.

1705. *Atmospheric Potential.* **E. Oddone.** (N. Cimento, 9. pp. 448–450, June, 1899.)—The author points out that the potential increases as we ascend in the atmosphere, and that it is not the potential, but the potential-gradient which diminishes. A. D.

1706. *Atmospheric Potential.* **H. Pellat.** (Paris, Soc. Franc. Phys. Bull. 134. pp. 1–2, June, 1899.)—The apparatus used by the author consists of a cylindrical brass tube about 25 cm. high and 20 cm. in diameter, surrounded at half its height by a circular gas-burner having a large number of holes, so that the flame is continuous. Even when exposed to a high wind the flame is not extinguished, one part being always protected by the cylinder and serving to relight the rest. Successful experiments have been made on the summit of the tower of the Sorbonne during a gale. The apparatus follows very rapidly the variations of potential of the air. A laboratory experiment shows that a variation of potential produced artificially is indicated after 15 seconds to within 0·4 per cent. of its value. A water-dropping electrometer using 60 litres per day would require 25 times that interval to give the same indication. The flame apparatus does not require very rigid insulation, an ebonite arrangement similar to telegraph insulators being sufficient. E. E. F.

1707. *Electrostatic Capacity of Two Parallel Wires.* **J. B. Pomey.** (Écl. Électr. 19. pp. 131–133, 1899.)—The author refers to the previous work of Blavier (Annales Télégraphiques, 1882) on this subject, and then gives an account of his own method of attacking the problem, which involves the use of functions of a complex variable. He obtains the following expression for the capacity C per unit length of the two parallel wires—

$$C = \frac{k}{2\log(\alpha + \sqrt{\alpha^2 - 1})}$$

in which k stands for the inductivity of the medium surrounding the wires, and $\alpha = (d^2 - R^2 - R'^2)/2RR'$, where d is the distance between the centres of the two wires whose radii are R and R′ respectively. A. H.

1708. *High-Frequency Point Discharges.* **F. Himstedt.** (Wied. Annalen, 68. 2. pp. 294–305, June, 1899.)—The author was the first to prove that if one pole of a Tesla transformer is connected with a point, and the other with a disc placed at such a distance that no spark is able to pass from one to the other, the disc is charged positively in air or oxygen, and negatively in all other gases. This result is independent of the direction of the primary current in the coil, or of the connection of the poles, the slight differences observed by Pflüger being due to a lack of symmetry in the experimental arrangement. Further investigations by the author led to very contradictory results, but these were due to a curious circumstance hitherto unobserved. He found that the disc is charged positively, negatively, or not at all, according to

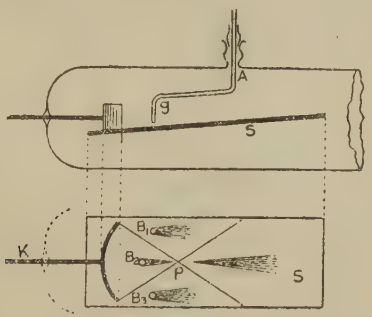
the distance between the point and the disc. To explain this, the author makes the assumption that a fine point attached to the pole of a Tesla transformer gives out a greater quantity of positive electricity than negative, and further, that the negative electricity is capable of being propagated to a greater distance through air than positive electricity. These rules characterise the discharges no matter what may be the nature of the gas, the only difference being that the transition takes place at different distances in different gases. E. E. F.

1709. *Flexible Spark Discharges.* **E. Lecher.** (Wied. Annalen, 68. 3. pp. 623–628, July, 1899.)—The author describes some extraordinary and beautiful phenomena obtained with a Wehnelt interrupter and a magnetic field He finds that the secondary current obtained with a Wehnelt interrupter is unidirectional, and corresponds with the break of the primary current only. Hence the secondary sparks may be employed for demonstrating the influence of a magnetic field upon a flexible conductor, a function which it fulfils with great brilliance of effect. It is well known that every spark discharge, as well as the arc, shows an upward curvature, partly at least due to an ascending current of heated air. If the discharge obtained with the Wehnelt interrupter takes place between two wires slightly inclined to each other, and symmetrical as regards the vertical, the lower ends being the nearest, the discharge sets in at the bottom, ascends under the influence of the hot air, and finally snaps at the top, to begin again as before. But when a powerful magnetic field is created at right angles to the plane of the wires the process is greatly accelerated, the lines of discharge succeeding each other at such a rate that they appear to form one flaming surface. On reversing the field the discharge remains at the bottom, and even curves downward unless much heat is developed. Another pretty effect is obtained by letting the discharge take place between a disc placed at the centre and in the plane of a vertical circular wire. The discharge normally goes straight up from the disc to the wire. But, on exciting the magnet, a kind of wheel is produced, having curved luminous spokes which revolve rapidly in a direction determined by the sign of the field. The spark lines are much closer together than shown in the figure. The author describes a number of other striking experiments illustrating the behaviour of these flexible discharge threads. They make good lecture experiments. E. E. F.

1710. *Phillips Phenomenon.* **S. P. Thompson.** (Electrician, 43. pp. 412–413, July 14, 1899.)—The author suggests an explanation of the Phillips Phenomenon (for which see 1899,

Abstract No. 683). The direction of rotation is consistent with the assumption that a current, or convective discharge, flows radially inwards. To account for the occurrence of the discharge only after exciting the magnetic field, it is suggested that the growing magnetic field sets up electrostatic forces, which act on the electric charges previously stationary. J. L. H.

1711. *Kathode Rays.* **A. Wehnelt.** (Wied. Annalen, 68. 3. pp. 584–593, July, 1899.)—The author endeavours to obtain a true explanation of the contradictory results obtained with regard to the shadows cast by kathode rays. He finds that the kathode rays which issue from the kathode in a direction normal to its surface cross each other freely, and do not mutually influence each other's direction. They therefore produce reversed



shadows of intervening obstacles. The upright shadows occasionally met with are due to another class of rays, which run parallel to the axis of the tube. The difference between the two classes of rays is brought out clearly by mounting a chalk screen S (see diagram) in a position nearly parallel to the axis of the tube. A glass rod *g*, capable of turning about the shaft A, casts a shadow of the shape shown at B_1, B_2, B_3, according to the kind of beam in which it is inserted. The kathode rays cross the point *p*.

E. E. F.

1712. *New Vacuum Phenomenon.* **L. Fomm.** (Wied. Annalen, 68. 3. pp. 620–622, July, 1899.)—When a vacuum tube is provided with two external electrodes in the shape of rings of thin wire surrounding the ends of a long thin tube, and is gradually exhausted, the well-known succession of phenomena is observed—spark discharge, positive and negative light, formation of dark space, and stratification of the positive light. Then blue rings appear, concentric with the wire rings, and enclosing particles of positive light, which gradually disappear until the blue light fills the whole cross section. As the pressure diminishes

still further the blue light detaches itself from the glass walls, and expands laterally while contracting in the plane of the rings, until a greenish-blue beam is formed proceeding in the direction of the other ring, but always perpendicular to the plane of the generating ring, whatever be the orientation of that ring with respect to the axis of the tube. The greyish-blue beam has all the properties of kathode rays, though its generation must necessarily be a very different process from that of the kathode rays. It produces vivid phosphorescence where it impinges upon the glass wall, sets in motion a little paddle wheel mounted in its path, and is deflected by a magnet, the centre of rotation being the geometrical centre of the ring. E. E. F.

1713. *Dielectric-Constants Determined by Electric Waves.* **L. Barbillion.** (Écl. Électr. 19. pp. 326–333, June 3, 1899.) —A *résumé* of the chief methods used by different observers for determining the dielectric-constants of various substances by means of electric waves of moderate length. E. H. B.

1714. *Electrical Oscillations in Variable Circuits.* **M. Petrovitch.** (Écl. Électr. 19. pp. 88–92 and 213–221, 1899.) —In the ordinary theory of condenser discharges the resistance, inductance, and capacity of the circuit are assumed to remain constant. The author deals with the case in which these quantities are supposed to be functions of the time. The method used does not necessitate the integration of the differential equation, and is based on certain properties of the integrals of linear differential equations of the second order in which the second term is absent, most of these properties having been discovered by Sturm. It is impossible to give a satisfactory abstract of the mathematical details of the paper. A. H.

1715. *Electrical Radiation.* **J. E. Taylor.** (Elect. Rev. 44. pp. 794–795 and 799–800, 1899.)—The theories of electrical radiation, especially as regards their application to wireless telegraphy, are here summed up in non-mathematical form, on the lines of Hertz, Lodge, J. J. Thomson, and Poynting. R. A.

1716. *Cohering Action of Metals.* **J. C. Bose.** (Roy. Soc. Proc. 65. pp. 166–172, July, 1899.)—The sensitiveness depends on the proper adjustment of the E.M.F. and pressure of contact for each particular receiver. All metals exhibit contact sensitiveness to electric radiation, the general tendency being towards a

diminution of resistance. Potassium is an exception: it exhibits an increase of resistance under the action of radiation, and also a remarkable power of self-recovery. The allied metals also exhibit, to a less extent, this increase of resistance. In damp climates coherers made of iron or steel become oxidised on the surface, and this change causes a diminution of the sensitiveness of the coherer. This can be avoided by coating the spirals with deposits of other metals, the sensitiveness depending on the coating metal and not on the substratum. Highly sensitive coherers can be made of fine silver threads coated electrolytically with cobalt.

D. E. J.

1717. *Action of Coherers.* **T. Sundorph.** (Wied. Annalen, 68. 3. pp. 594–597, July, 1899.)—The author demonstrates in a simple manner the formation of connecting chains of particles in a coherer. He attaches two metallic rods to a horizontal glass plate, with a distance of a few millimeters between them, and fills up the gap with a thin layer of powdered nickel or iron. He then imparts conductivity to the layer by means of sparking or by repeated short-circuiting. When that is done he removes the greater part of the metallic powder by means of a feeble magnet. What remains forms a set of rows of particles cohering lightly. If the magnet is too strong, these rows are broken up. The fact that the higher conductivity may be produced by short-circuiting suggests that the E.M.F. due to the break of the short-circuit produces sparking in the powder, which welds the particles together. On tapping the powder very gently, the high conductivity is reduced to a certain extent by the partial breaking up of the connecting links. But this may be remedied by diminishing the resistance in the remainder of the circuit. The fact that heating destroys the conductivity, while cooling does not, is explained by the author on the ground of the longitudinal pressure which breaks the heated rods, while they withstand a tension produced by cooling.

E. E. F.

1718. *Coherers.* **T. Tommasina.** (Comptes Rendus, 129. pp. 40–42, July 3, 1899.)—The process of coherence consists, in the author's opinion, in the formation of chains of filings; and the formation of the chains depends upon the orientation of the unit fragments under the influence of the electric field between the electrodes. The chains are formed less easily in air than in liquid dielectrics. In distilled water chains 20 cms. long have been made; the action is in this case not instantaneous, but it requires less than 1 sec. of time. The filings are first sprinkled over a large horizontal board. A coil giving a spark of 35 cm. was used by the author. The discharge, apparently, was caused to take place close to the board; the distance and position of the

electrodes is not definitely stated. By diminishing the current it is possible to form a set of chains; if the current is then gradually increased, one chain at last completes the circuit between the electrodes; the immediate effect is to break up all but this chain into fragments, and to cause all movement among the filings to cease. So long as the current is continued this chain is not easily destroyed, even when violently shaken; but if the current is broken, a very slight shake disintegrates it. Similar effects can be obtained by using a V-shaped glass tube to contain the distilled water. In another form of the experiment, filings of silver are sprinkled over a large flat dish, containing distilled water to 3 or 4 mm. Two aluminium wires are used as electrodes. Under the action of a current less intense than in the preceding experiments, chains of filings can be caused to radiate from the electrodes, perfectly identical in form with the magnetic lines of force between the poles of a magnet. But it is necessary to continually break the complete chains as they form, otherwise a perfect *fantôme* cannot be obtained. R. A.

1719. *New Form of Coherer.* **A. G. Dell.** (Elect. World and Engineer, 33. p. 839, June 17, 1899.)—A conical-shaped wooden vessel carries two wire terminals which pass through the sides, and is filled with brass filings which escape at the orifice formed by the lower part of the cone. As the filings run out they cause decoherence along the chains of filings between the points of the brass wires. The author finds it difficult to keep the filings running without frequent tapping, and suggests that by using glass instead of wood (*e.g.*, a vessel shaped like an hour-glass) this difficulty might be overcome. A. H.

1720. *Photographic Study of the Arc.* **N. H. Brown.** (Phys. Rev. 7. pp. 210–216, 1898.)—This paper is illustrated by plates taken from the photographs obtained.

An alternating arc is focussed by a lens on to a photographic plate moving rapidly horizontally. In some cases a narrow vertical slit is placed just in front of the plate giving better definition. The results show, not only that the arc is out part of the time, but also that the lighting up does not take place across the whole arc space at the same instant, starting from one side one time and the opposite side the next time. A simple calculation shows that this light travelled across the arc with a velocity of about 300 inches per second from the negative carbon towards the positive. From results obtained with the narrow slit in front of the plate, there appears to be two light fronts, one from each carbon, and one of them starts about $\frac{1}{1000}$ of a second before the other. They travel with different velocities, the negative at about

300 and the positive at 500 inches per second. Pictures were also taken of a whole arc, a disc with four slots in it being rapidly rotated in front of the lens at about 15,000 revolutions per minute, there being thus about 1,000 exposures (of $\frac{1}{2500}$ second each) per second, or about 8 images of the arc per complete period. The results of this experiment bear out the previous conclusions. A further experiment was made with a continuous current arc. This was short-circuited during part of the time while the plate was moving: before the plate had entirely passed across, the short circuit was broken, relighting the arc. When the arc is first broken an abrupt line is visible, showing a very sudden diminution of the light; the fading light from that line forward is the same as with the alternating arc. When the arc is re-formed, its difference from the alternating arc is very marked; the light does not reach the centre quite as soon as it leaves the sides, but very much sooner than in the case of the alternating arc. Also the light from the positive carbon is ahead of the negative, while in the alternating arc the negative is ahead of the positive. E. C. R.

1721. *Effect of Torsion on Electrical Resistance of Alloys.* **C. de Szily.** (Comptes Rendus, 128. pp. 927–930, 1899.)—In order to investigate the effect of variations of torsion upon the resistance of wires, it is necessary to eliminate the effects of temperature changes. As this is rather difficult, the author experimented with constantan, an alloy which has a temperature coefficient that can be neglected. The results of a great many experiments show that the electrical resistance augments as the angle of torsion increases. Up to the elastic limit of the metal, the variation appears to be directly proportional to the angle of torsion. But beyond the elastic limit of the metal, the resistance varies more rapidly than the torsion.

The author also examines the more important question as to whether the electrical resistance of such a stretched wire remains constant with time. In the case of constantan it is found that after being subjected to and maintained in torsion, the resistance very slowly diminishes with time. It is also found that a wire (presumably a wire of constantan) which, after dextral torsion, has been relieved, and then twisted by sinistral torsion, to the zero position, diminishes in resistance more quickly than when the initial twist is maintained. When a wire has been twisted beyond the elastic limit, and has then been allowed to untwist itself, the subsequent changes of resistances, for increasing angles of torsion, are less than those that occur during the first twist. Comparing torsional effects for wires of different diameter (presumably of constantan), it is found that the electrical resistance-changes augment more rapidly than the diameters. R. A.

1722. *Flames Containing Salt Vapours.* **H. A. Wilson.** (Roy. Soc. Proc. 65. pp. 120–123, June, 1899.)—Observations upon the conductivity of such flames. Ionisation takes place at the surfaces of the glowing electrodes and not throughout the volume of the flame. The velocity of the negative ions in the flame is very much greater than the corresponding velocity of the positive ions (about 1,000 as against 60 cm. sec. per volt cm., for salts of Li, Na, K, Rb, Cs). Those ions which in solutions carry equal charges have equal velocities in the gaseous state; but have less velocities than those calculated for single atoms. A. D.

1723. *Measurement of Battery Insulation.* **C. Liebenow.** (Elektrotechn. Ztschr. 20. pp. 360–362, 1899. A paper read before the Elektrotechnischen Vereins, April 25, 1899.)—In the usual method of testing the insulation resistance of a battery of accumulators by placing a voltmeter between earth and the two poles of the battery in turn, the leakage is all assumed to be from one point, whereas the fault is really split up into many parts. In examining the relations which exist, we may neglect the internal resistance of the battery as compared with its insulation resistance, and we can therefore regard the battery as a resistance-less conductor, along which a series of E.M.Fs. are arranged.

If $l_1, l_2 \ldots l_n$, are the conductivities of small parts of the battery between which the difference of potential is de (where $n.de = E$), and if i_1 and i_2 are respectively the currents to earth through a resistance-less ammeter from the two poles of the battery, then :—

$$i_1 = l_1\,de + 2.l_2\,de + 3.l_3\,de + \ldots + (n-2).l_{(n-2)}\,de + (n-1).l_{(n-1)}\,de + n.l_n\,de.$$

$$i_2 = n.l_0\,de + (n-1).l_1\,de + \ldots + 2.l_{(n-2)}\,de + l_{(n-1)}\,de.$$

Adding, we get $i_1 + i_2 = n.de\,\Sigma l = EL = \frac{E}{W}$, where E, W, and L, are respectively the E.M.F., resistance, and conductivity of the whole battery. If, however, accuracy is desired in the case of a very high insulation resistance, we must use a sensitive ammeter or galvanometer whose resistance will not be negligible. We must then insert an auxiliary battery, very carefully insulated, between the galvanometer and the main battery in such a way that their E.M.Fs. add. Then if e and w are the E.M.F. and resistance of the auxiliary battery, and if w_1 is the resistance of the galvanometer, then $W + w + w_1 = \frac{E + 2e}{i_1 + i_2}$.

If w and w_1 are not known, we can put an auxiliary galvanometer directly between the pole being measured and earth. If we now adjust a variable resistance between the ammeter and

auxiliary battery until no current passes through the auxiliary galvanometer, then the simple formula $W = \frac{E}{i_1 + i_2}$ again holds.

E. H. C.-H.

1724. *Electrical Measurements with Alternating Currents.* **H. A. Rowland** and **T. D. Penniman.** (Amer. Journ. Sci. 8. pp. 35–57, July, 1899.)—The paper details the results of measurements of capacity and self-induction by the methods published by Rowland (Amer. Journ. Sci. 4. p. 429, December, 1897; Phil. Mag. January, 1898. See 1898, Abstract No. 144), employing alternating currents and an electro-dynamometer. The authors first tried their method, No. 25 (*loc. cit.*), for the absolute measurement of self-induction and capacity in terms of the electromagnetic units. With self-induction the results were very concordant, agreeing within the accuracy of the frequency measurements, *i.e.*, to within 1 per cent. With capacity the determinations were vitiated by the absorption effect of the paraffined-paper condensers adopted.

Maxwell's formula shows that absorption may be treated as an added resistance which is constant for a given frequency, and the values of this for different frequencies were calculated, and found to agree well with the values found by direct measurement. The resistance increases rapidly with decrease of frequency; thus a 5-mf. condenser had an absorption resistance of about 5 ohms at a frequency of 130 $\sim$ and 140 ohms at 14 $\sim$. It also increases with the temperature of the condenser, for instance, after heating the condenser for one hour before a hot-air pipe, the resistance increased about 50 per cent.

An improved method is then described specially suitable for measuring absorption resistances.

The rest of the paper consists of detailed results of experiments with methods 12 and 6, zero methods for the comparison of self-inductances with one another and with capacity; different determinations agree to within 0·1 per cent. G. H. Ba.

1725. *Polarisation of de-ærated Water.* **R. Federico.** (N. Cimento, 9. pp. 191–206, 1899.)—The maximum E.M.F. of polarisation is less in water which contains gas in solution than in water free from gas (obtained by distilling crystallised carbonate of soda). Among oxygen, hydrogen, nitrogen, and air, oxygen has the greatest effect, then air, then hydrogen, and the action of nitrogen is not sensible. The action of air seems to depend upon the oxygen in it. A. D.

1726. *Polarisation of Dielectrics.* **Liénard.** (Comptes Rendus, 128. pp. 1568–1569, June 26, 1899.)—The author

shows that not only does the theory of the fictitious polarisation of dielectrics lead to the same consequences as the other theories in one case (see Pellat, Science Abstracts No. 1159, 1899), but that it does so in all cases. E. E. F.

1727. *Electro-chemical Equivalent of Silver.* **G. W. Patterson, Jr.**, and **K. E. Guthe.** (Amer. Assoc. Proc. 47. pp. 154–175, 1898.)—In measurements of the electrochemical equivalent of silver the value has usually depended upon the accurate knowledge either of the acceleration due to gravity or of the horizontal intensity of the earth's magnetic field. The authors have obtained a value independent of g or H by balancing the moment due to the electrodynamic action of the two coils of an absolute electrodynamometer, against the torsional moment of a wire with very small elastic fatigue. The measurements are finally reduced to measurements of mass and length and the authors believe their result to be accurate to 1 in 5,000.

In the determination, Poggendorff's potentiometer method was used for comparing electromotive forces. First the ratio was found between the E.M.F. of two Carhart-Clark cells immersed in a large water-bath and the potential difference at the terminals of a coil of manganin wire, when a current flowed through it which just balanced the torsional moment of the suspending wire of the electrodynamometer due to one complete twist of the torsion head. The absolute value of this current was calculated from the instrument. Let I be the calculated current, E the E.M.F. of the cells, R_1 the resistance necessary to balance E, R_2 the resistance necessary to balance the potential difference due to I, R the resistance of the manganin coil, then—

$$I = \frac{R_2 E}{R_1 R}.$$

Secondly, the E.M.F. of the cells was balanced against the potential difference due to the silver depositing current. Let I_1 be this current, R'_1 and R'_2 the resistances necessary for the balances, E and R the same as before, then—

$$I_1 = \frac{R'_2}{R'_1} \cdot \frac{E}{R}.$$

The silver deposited by the current I is—

$$q = z I_1 t \text{ grammes},$$

where z is the electrochemical equivalent of silver, but—

$$I_1 = I \frac{R_1}{R_2} \cdot \frac{R'_2}{R_1}.$$

therefore—

$$z = \frac{q}{It} \cdot \frac{R'_1}{R_1} \frac{R_2}{R'_2},$$

and the result is independent of the absolute value of the E.M.F. of the standard cells and of the manganin resistance coil.

A full account is given of the construction and adjustment of the electrodynamometer, the determination of the torsional coefficient of the phosphor-bronze suspension, and of the periods of torsional vibration of the system, as well as the influence of temperature upon the period. In the final experiments the moment of torsion due to a complete twist of the wire was balanced against the electrodynamic action between the two coils of the electrodynamometer.

The value found for the electrochemical equivalent of silver is—

$$z = 0{\cdot}00111{\cdot}92 \text{ grammes.}$$

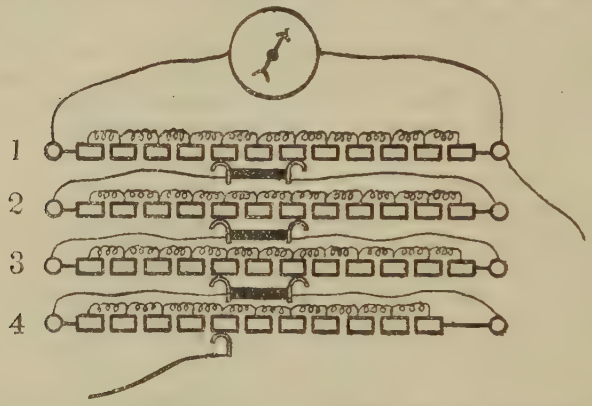
This is about $\frac{1}{9}$ per cent. larger than the accepted value. It agrees with the average value of Pellat and Potier, and with the value given by Kahle in a preliminary report on his experiments in Berlin with Helmholtz's current-balance when an old solution of silver nitrate was used. In this case Kahle's value is 0·00111193, and when the silver was deposited from a freshly prepared solution 0·00111182. (See also 1899, Abstract No. 109.)

J. J. S.

1728. *Wehnelt's Interrupter.* **A. Voller** and **B. Walter.** (Wied. Annalen, 68. 3. pp. 526–552, July, 1899.)—The spectroscopic analysis of the spark produced in the Wehnelt interrupter at break gives some valuable hints as to the nature of the process of interruption. The red colour of the spark suggested to the authors the presence of an excess of hydrogen vapour, and an analysis of the vapour disengaged at the anode proved, in fact, that its amount was two and a half times the normal amount demanded by Faraday's law. The hydrogen lines are very clearly evident in the spectrum. Platinum lines are also distinctly visible, and very pure and intense spectra of other metals may be produced by putting them in place of the platinum, and especially by reversing the ordinary action of the cell and making them kathodes. The presence of the hydrogen and of the sodium lines is not a disadvantage, as these are easily located and serve as lines of reference. By choosing a suitable electrolyte, the rapid disintegration of the majority of metals can be avoided. It should also be borne in mind that the spectrum lines of a metal may be obtained in two different ways with the same induction coil, by putting the cell either in the primary or the secondary circuit. E. E. F.

1729. *Concentration Cells.* **R. Salvadori.** (Roma R. Accad. Lincei Atti, 8. pp. 452–454, 1899.)—E.M.Fs. are given of cells made up of zinc electrodes surrounded by solutions of hydrochloric acid or trichloracetic acid of various concentrations, the solvents being water, alcohol, acetone, benzol, or ether. Also of cells containing KCl dissolved in those organic liquids, and provided with copper and zinc electrodes. E. E. F.

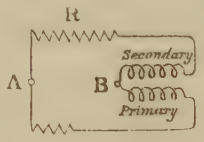
1730. *Universal Shunt.* (Elect. Rev. 44. p. 715, 1899.)—This is a description of a special universal shunt of the Ayrton-Mather form designed by Sullivan, in which the principle of the Thomson-Varley slide resistance is applied. Eleven coils of 1,000 ohms each are employed and the subdivision is carried down to one ohm. The accompanying figure shows the method of connection. The actual connections are made by means of sliding contacts over the studs of four sets of coils, No. 1 set of which contains eleven coils of 1,000 ohms each, No. 2 eleven coils of 200 ohms, No. 3 eleven coils of 40 ohms, and No. 4 ten coils of 8 ohms each. Two sliding contact springs insulated from each other ride over and embrace two coils of Nos. 1, 2, and 3 sets, and each pair of coils



so embraced is permanently in parallel with all the coils in the next lower set. No. 4 sliding contact is a single one.

The box contains in addition an independent coil of 100,000 ohms. W. G. R.

1731. *Production of Leading Currents.* **O. Spitzer.** (Zeitschr. Elektrotechn. Wien, 17. pp. 213–216, 1899.)—In a given non-inductive circuit, R (see fig.), to produce a current in advance of the P.D. between two points A and B, without the use of con-



densers or synchronous motors. The author solves this problem by connecting the secondary of a transformer in series with R between A and B, the primary being connected in series with another non-inductive resistance between the same two points. By varying the resistance in series with the primary, the phase

relation of the current in R to the P.D. between A and B may be varied. The theory of the arrangement is fully worked out, and is extended to the case of an inductive circuit. A. H.

1732. *Alternating Current Circuits.* **De Bast.** (Bull. Ass. Ing. El. Liège, 10. pp. 48–84. 133–160, 233–255, 1898–1899.)—This paper contains elementary proofs of the relations between current, electromotive force, and reactance in circuits containing resistance, inductance, and capacity, either separately or in combination. W. G. R.

1733. *Electromotive Force on Mixing Liquids in a Magnetic Field.* **R. Blondlot.** (Comptes Rendus, 128. pp. 901–904, 1899.)—A rectangular vessel, $18 \times 12 \times 23$ cm. deep, is filled to a depth of 3 cm. with a concentrated solution of zinc sulphate, the remainder being filled with a weak solution of the same salt, care being taken to avoid mixing. Two glass tubes pass through two of the opposite vertical faces at a height of 4 cm. from the base. These tubes are closed at the outer ends by paper parchment and are filled with solution from the vessel itself. They are bent downwards so that the ends dip into two little vessels containing a solution of zinc sulphate, each of these little vessels also containing an electrode of zinc amalgam. These electrodes are connected to the terminals of a capillary electrometer. The large vessel is placed between the poles of an electromagnet so that the lines of force are horizontal and parallel to the two sides containing the tube attachments.

A stirrer in the shape of a T square is now put into the liquid and as soon as any stirring takes place a difference of potential is noticed on the electrometer, this difference of potential changing sign with a reversal of the magnetic field. The difference of potential disappears when the stirring stops, and also when the magnetic field is removed. If we suppose a person lying on his right side in the vessel and facing the north-seeking pole of the magnet, then the positive electrode is at his head. The expression for the E.M.F. due to induction between the terminals is an integral, containing, among other things, the variable conductivity of the solution. If we remember that the mean effect of the stirring produces homogeneity, it is seen that this integral is not zero, but has a positive value that agrees with the experiments.

J. B. H.

1734. *Magnetic Inclination in Ancient Times.* **G. Folgheraiter.** (Roma R. Accad. Lincei Atti, 8. pp. 269–275, 1899.)—The article is an amplification and continuation of a paper referred to in Abstract No. 1039 (1899). In Greece during

the seventh century B.C., the *south* pole of the dipping needle probably dipped downwards. This is different from its present behaviour. A. Gs.

1735. *Momentary Magnetisation.* **W. Kaufmann.** (Verh. Deutsch. Phys. Gesell. 1. pp. 42–46, 1899.)—If the needle of a magnetometer is replaced by an oscillating coil, no deflecting couple acts upon the latter unless it is traversed by a current. If an interrupter attached to the shaft of alternator is inserted in the circuit of the coil, which only makes the circuit at a definite phase, the force exerted by the magnet upon the coil is proportional to the instantaneous magnetisation of that phase. The author describes a magnetometer based upon this principle by which he has succeeded in showing that the hysteresis curves deduced from instantaneous values are identical with the ordinary ones. E. E. F.

1736. *Effect of Temperature on Hysteresis.* **A. H. Thiessen.** (Phys. Rev. 8. pp. 65–79, 1899, Abstract in Électricien, 17. pp. 375–377, June 17, 1899.)—These experiments, made at temperatures of 100° C., ordinary temperature, and about −80° C., show that the loss of energy dissipated by hysteresis increases as the temperature diminishes, but only when the induction is high enough to make the iron nearly saturated. When the induction is weak, the results are quite different, as the hysteresis loss diminishes with the temperature. Curves given in the paper show pretty clearly the reason of this phenomenon. The magnetising force being the same, the induction diminishes with the temperature as well as the hysteresis loss. For example, at a temperature of 97° C. the induction is 2,400, and the loss of energy 433 ergs; at 21° C. the induction is 1,900 and the loss 371 ergs; and at −78° C. the induction is 1,500 and the loss 266 ergs.

The diminution of the hysteresis losses is explained by the diminution of the induction for the same magnetising force. It is pretty certain that Steinmetz's law $\gamma = B^{1.6}$ holds at all temperatures between ±100° C.

It follows from the above, that if a transformer is worked at a low induction, the losses in the iron will augment as it heats up; if, however, it is worked at a sufficiently high induction the losses will be independent of the temperature.

Again, to magnetise a piece of steel, if only a weak magnetising force is at disposal, it is best to work at a temperature of about 100° C. E. C. R.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

1737. *Victorium, a New Element.* **W. Crookes.** (Roy. Soc. Proc. 65. pp. 237–243, July, 1899.)—Crude yttria is roughly freed by the double potassium sulphate method from earths of the cerium group, then subjected to fractionation, the important point being that the agent is changed when the one process has been in operation for some time. In the first stage the nitrates are fused till partially decomposed, and the insoluble basic salt separated by water from the undecomposed portion. This is repeated as long as the spectra of the fractions reveal progressive change. The more insoluble of the middle fractions have been gradually acquiring a distinctive spectrum; they are united and treated to a second series of fractionations by crystallisation of the oxalates. Photo-spectroscopic tests are constantly taken, and portions mixed according to the data thus obtained, to avoid lateral spreading as much as possible. In the third stage the selected oxalates are turned into nitrates and again fractionally separated by fusion. Finally the potassium sulphate method is once more applied till no more alteration in the spectrum is observed. A diagram is given.

Victoria (announced by the author at the British Association in September last under the name of *monia*) is a pale brown earth easily soluble in acids, less basic than yttria but more so than most earths of the terbia group, and distinctive in many characters. Taking its formula as Vc_2O_3, *victorium* will be about 117. The phosphorescent spectrum of the anhydrous sulphate shows a pair of strong lines at λ 3120 and 3117, and weaker ones at 3219, 3064, and 3060. The form of spectroscope used is described and illustrated. S. R.

1738. *Solution of Gases in Liquids.* **C. Bohr.** (Wied. Annalen, 68. 3. pp. 500–525, July, 1899.)—In order to find a simple relation between the temperature and the absorption of a gas in a liquid, the author breaks up the absorption coefficient into an "invasion" and an "evasion" coefficient, governing the entrance of the gas into the liquid and its exit respectively. The invasion coefficient is the product of the absorption coefficient into the evasion coefficient. It is constant for most liquids between 5° and 20°, but theoretically proportional to the square root of the absolute temperature. E. E. F.

1739. *Action of Gases on Caoutchouc.* **D'Arsonval.** (Comptes Rendus, 128. pp. 1545–1546, June 26, 1899.)—Pieces of indiarubber tubing exposed to gaseous carbonic

anhydride under pressures of 1 to 50 atmos. increase in volume considerably and absorb large quantities of the gas. When exposed to the air the rubber returns in about an hour to its original state. Carbonic anhydride passes very rapidly through an ordinary pneumatic tyre inflated with it. When the tyre was inflated with air it slowly became deflated. This deflation ceases after a time, however, if the pressure is maintained constant by pumping in fresh air. The tyre is then found to contain almost pure nitrogen, owing to the fact that oxygen passes through india-rubber much more readily than nitrogen. T. E.

1740. *Pseudo-Precipitation.* **J. Stark.** (Wied. Annalen, 68. 1. pp. 117–124, 1899.)—If an aqueous salt solution is added to water containing fine particles in suspension, the latter are deposited as a rule more rapidly than otherwise, thus giving the appearance of a chemical precipitation. The precipitate is also as a rule flaky. Various explanations, based upon surface tension, cohesion, viscosity, and concentration, have been given of the phenomenon. The author points out the instances in which these explanations fail, and puts forward a view based upon the super-saturation of the liquid with air, which is deposited on the particles. The latter, therefore, have a function analogous to that in the formation of clouds. River-mouth deposits are due to pseudo-precipitation. E. E. F.

1741. *Coagulation of Colloid Solutions.* **J. Stark.** (Wied. Annalen, 68. 3. pp. 618–619, July, 1899.)—The theory advanced by Barus for explaining the formation of flakes in liquids holding coarse particles in suspension does not apply to precipitations of colloids. Colloid solutions are not solutions properly so called, but consist of matter in suspension. This is certainly the case with colloidal, metallic, and sulphide solutions. When a gold sulphide solution is precipitated by zinc chloride the flakes show countless air-bubbles, and when brought under an air-pump they rise to the surface and give off a good deal of air. E. E. F.

1742. *Solution Theory of Iron and Steel.* **H. J. von Jonstorff.** (Indus. and Iron, 26. pp. 425–427, June 2nd; 442–443, June 9th; 463–464, June 16th; 486–488, June 23, 1899.)—The author further develops his calculations (see 1899, Abstract No. 848) of the molecular weights of carbon, of carbides, silicides and phosphides of iron, of nickel, &c., when dissolved in liquid or solid iron, and finds evidence of a series of molecules whose complexity decreases as the temperature rises. The chemical behaviour of steel and iron, especially towards nitric acid in the

colorimetric determination of carbon, is considered at length in connection with the results obtained.

As in the previous paper, the experimental data appear to be insufficiently precise to afford reliable results. T. E.

1743. *Theory of Lead Accumulators.* **K. Elbs.** (Zeitschr. Elektrochem. 6. pp. 46–52, July 13, 1899.)—The author maintains that the production of lead peroxide in the charging of an accumulator is due to hydrolytic decomposition of lead bisulphate, $Pb(SO_4)_2$, and not, as Liebenow supposes, to the direct discharge of PbO_2 ions. The first view involves, it is true, an irreversible loss of energy, but this is probably small in amount, and Dolezalek's experiments (see 1898, Abstract No. 689) are not considered sufficiently accurate to disprove the occurrence of such a loss. In support of his view the author urges that the existence of PbO_2 ions has only been demonstrated in the case of alkaline solutions, and that it is very improbable that they exist in acid solutions, whereas various salts of tetravalent lead are known to be more or less readily decomposed by water with formation of lead peroxide. Moreover, the fact that peroxides of zinc and copper are not deposited from alkaline solutions of these metals, although ZnO_2 and CuO_2 ions are evidently present, is in harmony with the author's theory, since zinc and copper, unlike lead, are incapable of becoming tetravalent and forming salts analogous to $Pb(SO_4)_2$.

In the discussion that followed, **Nernst** considered that the decomposition of unstable compounds such as lead bisulphate would necessarily involve the loss of an amount of energy quite irreconcilable with the results of Dolezalek's experiments. The existence of PbO_2 ions in acid solutions in small number was quite conceivable, and was all that was required for Liebenow's theory. **Le Blanc** was of the opinion that several processes, and not one alone, were concerned in the charging of accumulators. **W. Ostwald** expressed his agreement with Le Blanc's views, and pointed out that the hydrolytic decomposition of lead bisulphate was a reversible reaction. N. L.

1744. *Electromotive Behaviour of Chromium.* **Hittorf.** (Zeitschr. Elektrochem. 6. pp. 6–10, July 6, 1899.)—Further observations tend to show that the peculiar variation of the electromotive behaviour of chromium with its chemical state cannot be attributed to the formation of a thin layer of oxide on the surface of the metal. Mainly of chemical interest. (See also 1898, Abstract No. 1072.) N. L.

1745. *Zinc and Cadmium Amalgams.* **T. W. Richards** and **G. N. Lewis.** (Amer. Acad. Proc. 34. pp. 87–99, 1898.) —Some electrochemical and thermochemical relations of zinc and cadmium amalgams were studied by determining the electromotive forces at varying temperatures of the following classes of cells: (1) electrodes of cadmium amalgam of different concentrations; (2) electrodes of zinc amalgam of different concentrations; (3) Solid cadmium electrode opposed to cadmium amalgam; (4) Solid zinc electrode opposed to zinc amalgam.

The main conclusions arrived at are as follow:—

1. A convenient method of measuring E.M.F. directly to a high degree of accuracy is described.

2. Cadmium amalgams as far as concentrations of 3 per cent., and zinc amalgams to concentrations of at least 1 per cent. obey closely the laws of dilute solution.

3. The use of the Helmholtz equation for the temperature coefficient of a cell offers in these cases an accurate method of determining thermal quantities.

4. The heat of amalgamation of cadmium is thus found to be + 505 gramme calories.

5. That of zinc as thus found is − 2255 gramme calories.

6. A solid electrode composed of finely divided electrolysed metal gives a very constant and reliable potential.

7. In the case of cadmium, the contact-potential given by the saturated amalgam in reversible relation to an electrolyte differs by the twentieth of a volt from that given by the metal.

8. In the case of zinc this difference is very slight. J. J. S.

1746. *Vapour-pressure of Solutions.* **R. A. Lehfeldt.** (Phil. Mag. 48. pp. 215–217, August, 1899.)— Nernst's relation between the vapour-pressures of a solvent when pure and when dissolving a small amount of solute, viz., that they are in the ratio of the molecular fractional amounts of the solvent in the liquid and vapour respectively, is tested by measurements on mixtures detailed in another paper (see 1899, Abstract No. 61). The relation is satisfied by carbon tetrachloride and either toluene or benzene, but not by alcohol with either of these liquids.

R. E. B.

1747. *Cryoscopic Behaviour of Alcohols.* **W. Biltz.** (Zeitschr. Phys. Chem. 29. pp. 249 265, June, 1899. Compare Zeitschr. Phys. Chem. 27. p. 529, 1898).—The author has determined the molecular weight of a large number of alcohols from the freezing-point of solutions in benzene of varying concentrations. In all cases a rise of molecular weight occurs as the concentration increases. The results have been plotted in the form of curves. Among the primary alcohols the deviations are greatest for the lower homo-

logues, but in solutions of equal concentrations they are nearly the same for all the higher members of the series. On comparing isomeric alcohols the primary members of the series show greater deviations than the secondary and tertiary; this difference is especially marked where the molecular weight is large and may serve as an indication of the group to which an alcohol of unknown constitution should be assigned.

The results obtained are in accordance with those of Ramsay and Shields (Zeit. Phys. Chem. 12. 468, 1893), on the molecular weight of liquids, and of Traube (Ber. 29. 1027, 1896) on the covolumes of the alcohols. T. M. L.

1748. *Electro-Deposition of Brass.* **T. J. Baker** and **T. J. Baker, Jr.** (Chem. News, 80. p. 37, July 28, 1899).—The precipitate, produced by adding KCN to a cold solution of $CuSO_4$, is regarded as cupric cyanide, which, on boiling, passes into cuprous cyanide by losing $(CN)_2$. Both compounds are soluble in KCN, and these solutions are used for the electro-deposition of copper and of brass. The brass solutions deposit more metal than a copper sulphate bath, placed in series with them. The authors electrolysed the cyanides of copper and zinc, and their mixtures, with a kathode of platinum, fitted over a glass tube, and a concentric anode cylinder. They conclude that the cyanide always deposits the copper in the cuprous state. There are notable differences, however, between their calculated and observed values, which they attribute to the solvent action exercised by KCN on copper and on zinc. H. B.

1749. *Electrodeposition of Palladium.* **S. Cowper-Coles.** (Chem. News, 79. p. 280, June 16, 1899.)—A thin layer of palladium—70 to 80 grains per square foot—is found to form a good protective and reflecting surface for parabolic reflectors. The metal is deposited quite bright from a dilute solution of palladium ammonium chloride, operating at a temperature of 75° F. with a current density of 0·12 ampere per square foot, the E.M.F. at the terminals of the bath being 4–5 volts. The anode may be either palladium foil or carbon. N. L.

1750. *Electrolytic Estimation of Zinc.* **H. Paweck.** (Zeitschr. Elektrochem. 5. pp. 221–224, 1898.)—This paper describes a number of experiments made with the object of overcoming the disadvantages attending the usual methods for the electrolytic estimation of zinc. The chief improvement suggested consists in the use, for the kathode, of a disc of brass wire net, 6 cm. in diameter, the meshes of the net having

an area of about 1 sq. mm. Upon this the metal is deposited, either from an alkaline solution containing caustic potash or soda and Rochelle salt, or from an acid solution to which sodium or potassium sulphate is also added. In the former case the brass net is previously amalgamated. Both methods give accurate results. N. L.

1751. *Electrolytic Analysis.* **G. Arth.** (Écl. Électr. 19. p. 338, June 3, 1899.)—The statements of Avery and Dales as to the impurities contained in iron deposited from oxalic solution, are controverted by H. Verwer and F. Groll (Berich. der deuts. Chem. Gesell. p. 806, 1899) who maintain that iron may be accurately estimated by electrolysis at 50–60° with a current of 0·95–1·1 amperes at 2·5–3·0 volts, the metal thus obtained being found by analysis to be free from carbon and other impurities.

E. F. Smith and D. Wallace (Electrochemische Zeitschrift, p. 167, 1898) reply to the objections raised to their work by Heydenreich and bring forward fresh experimental results to show that uranium may be completely deposited from acetic acid solution by electrolysis at 70° for six hours, with a current $D_{40} = 0{\cdot}18$ ampere at 3 volts. Cadmium in the presence of sodium phosphate and free phosphoric acid may also be accurately estimated, the electrolysis being carried on for seven hours at 50° with a current increasing from D.N = 0·06 ampere at 3 volts to 0·35 ampere at 7 volts. N. L.

1752. *Electrolysis of Hydrochloric Acid.* **Haber** and **Grinberg.** (Zeitschr. Elektrochem. 5. pp. 557–560, June 8, 1899: from Zeit. anorg. Chem. 16. pp. 198–228, 329–361, 438–449, 1898.)—The first part of this paper deals with the electrolysis of hydrochloric acid of various degrees of concentration between platinum electrodes at the ordinary temperature. With the concentrated acid, chlorine is evolved at the anode in theoretical quantity, and the amount decreases on dilution until only a small percentage is formed. Traces of hypochlorous acid are formed in the electrolysis of the dilute acid. Chloric acid, to the extent of one third of the theoretically possible yield, is produced when acid of normal to one-third normal strength is used: it is accompanied by traces of hydrogen peroxide. With very dilute acid, perchloric acid in one-fourth of the theoretical yield is produced. Oxygen is also evolved at the anode, amounting to 40 per cent. in dilute acid. The results obtained are discussed theoretically from the point of view of the ionisation hypothesis.

In the second part of the paper the authors examine the behaviour of the acid when partially neutralised by the addition of bases, and the influence of temperature on the course of electrolysis is studied. The presence of bases, contrary to antici-

pation,appears to have little influence on the quantity of oxygen obtained from dilute acids. Heating the acid increases the yield of oxygen and decreases that of chloric acid.

The third paper deals with the conditions influencing the corrosive action of the acid on the electrodes. At the ordinary temperature platinum electrodes are unattacked by acid of less than 30 per cent. strength, whereas at the boiling-point some solvent action is observed with 11 per cent. acid. Platin-iridium containing 25 per cent. of iridium is unattacked by the hot, strong acid, and that containing 10 per cent. of iridium is but slightly attacked. During electrolysis the formation of platinum black is observed at the kathode. This is not due to transference from the anode, since the kathode suffers a loss in weight. A similar action is noticed in the case of lead, and it is possible to obtain a spongy lead kathode, although of comparatively small capacity, by the electrolysis of sulphuric acid between lead electrodes.

N. L.

1753. *Electrolysis of Benzoic Acid.* C. Schall. (Zeitschr. Elektrochem. 6. pp. 102–103, July 27, 1899.)—Electrolysis of a solution of sodium benzoate in fused benzoic acid, using an E.M.F. of 100 volts, results in the production of small quantities of diphenyl and other hydrocarbons. N. L.

1754. *Electrolytic Generators and their Work.* (Elect. World and Engineer, 33. pp. 817–819, June 10, 1899.)—This is a well-illustrated description of the electric generating plant in use at the Boston and Montana Copper and Silver Mining Co., Great Falls, Montana. There is, too, a short outline of the principles of electrolytic copper refining. The plant consists of a twin water-wheel, supplied by the Drayton Globe Iron Works, developing 2,900 H.P., at 130 revs. per minute. This is directly connected to two Westinghouse generators of nominally 810 kw. power, but guaranteed up to 1,210 kw. The brush mechanism and switchboard arrangements are also noticed. There is, finally, a list of the electrical machinery in use for copper refining at the Anaconda Copper Mining Co. of Montana. J. L. F. V.

1755. *Sterilisation of Water by Ozone.* J. Blondin. (Écl. Électr. 20. pp. 127–131, July 29, 1899.)—Since 1891, the sterilisation of water by means of ozone has been the subject of numberless investigations. The author refers to some of the earlier of these, and then passes on to a description of the apparatus designed by Marmier and Abraham, and of the results obtained by them at Lille in 1898–99. The installation com-

prises an alternating current generator, a transformer giving 30,000 volts at the terminals of the secondary, a plate ozoniser and an absorbing tower. The special form of ozoniser used has each of the metallic electrodes enclosed between two glass plates. The electrodes are kept cool by means of water. The absorbing tower is built of masonry.

Tables are given showing the chemical and bacterial character of the water before and after treatment with ozone. The ozonised air passed into the absorbing tower contained between 5·8 m. grs. and 9·5 m. grs. ozone per litre. The organic matter was reduced from ·014 grm. per litre to ·003 grm. per litre, and the bacteria in several instances were completely destroyed, while in other cases they were greatly reduced in number and activity. It was noticed that the results were best when the bacterial examination of the water did not *immediately follow* the treatment in the ozonising tower.

The report of the Commission appointed by the Municipal Council of Lille to examine the apparatus and process is given as a note to the article. This report is favourable to the method, and recommends the adoption of the Marmier and Abraham sterilising process at Lille, where the present water supply is contaminated, and typhoid fever is prevalent.

The author in conclusion discusses the question of cost, and expresses his regret that Marmier and Abraham have not supplied the necessary data to enable this to be accurately fixed. He refers to Andreoli's claim (see Abstract No. 1756) to have designed an ozoniser giving more economical results than the form used at Lille, but points out that in the absence of more complete data it is impossible to compare the results obtained by the two forms of ozoniser and systems of treatment. J. B. C. K.

1756. *Sterilising Water by Ozone.* **E. Andreoli.** (Elect. Rev. 44. pp. 749-750, 1899.)—The author refers to a report by certain French doctors upon the experiments carried out by Marmier and Abraham at Lille relating to the sterilisation of water by ozone. After criticising the form of ozoniser used, he quotes several passages of this report, in which the efficiency of ozone as a germicide is proved.

The author next discusses the question of cost, and states his opinion that the 2 centimes per cubic metre, given by Marmier in an earlier paper, is too high. In order to throw further light upon this question Andreoli has himself recently carried out experiments in London, and has measured the consumption of ozone in terms of electrical energy. The experimental plant consisted of a small Andreoli ozoniser worked at a tension of 3,500 volts, a Roots blower for forcing the ozonised air through the water, and five tanks in which the absorption of ozone by the water occurred. The plant permitted the treatment of 440 gallons

water per hour. A table is given showing the effects obtained, with expenditures of electrical energy, varying from 138 to 316 watts per cubic metre (220 gallons) of water.

The author concludes from his experiments upon Thames water that complete sterilisation of water drawn from the river at specially selected spots could be obtained, with an expenditure of electrical energy equal to 100 watt-hours per cubic metre of water.

J. B. C. K.

1757. *Electrolytic Zinc Extraction.* **J. B. C. Kershaw.** (Elect. Rev. 45. pp. 36–37, July 7, and p. 43, July 14, 1899.)—This is a full account of the various processes which have been tried for the electrolytic extraction of zinc from poor or refractory ores.

The Ashcroft process is first dealt with, and the chief causes of its failure are explained, one of the foremost being the falling off of the metallic contents of the ore to be treated. The extraction of zinc from zinciferous pyrites formed the main object of the Dieffenbach process, some time in industrial operations at Duisburg, in Germany, but according to various accounts the cost of extraction of zinc is twice that of the ordinary methods in use. Further mention is made of the Siemens and Halske process which was to be tried at Lake Illawara, N.S.W., and also the Nahnsen process some time at work at Lipine, Silesia, but financial failures have to be recorded of both methods. The Höpfner process, which has been taken up by Brunner, Mond and Co., employs revolving kathodes, and is said to have yielded 400 tons of zinc in 1897. Zinc and other chlorides form the electrolyte, and the simultaneous production of chlorine is also aimed at. Rotating zinc or aluminium kathodes are likewise employed in the Cowper-Coles process, which has been tried both in England and in N.S.W. with a negative result. At St. Petersburg 714 tons of zinc are said to have been produced by the Hernek process, according to a general account without details by Dr. Rostin. A dry process which differs from all preceding ones is the Swinburne method, in which the ore is fused with certain salts which act as a solvent, the various metals being separated by the current.

The author arrives at the conclusion that wet zinc extraction processes are only feasible in exceptional cases, and that further developments will lie more in the direction of dry or fusion methods.

O. J. S.

1758. *Electrolytic Soda and Bleach by Solway Process.* **G. H. Robertson.** (Electrician, 43. p. 226, June 9, 1899.)—This process is a combination of the mercury and gravity processes. Advantage is taken of the fact that the amalgam of sodium and mercury is lighter than the latter metal, and floats upon it. A sill or weir at one end of the cell retains the unamalgamated mercury,

and by the continuous circulation of the metal the amalgam is carried over this weir into a separate vessel, where it is decomposed.

The solution used in the cell is not homogeneous, but is composed of two layers. The lower one is in contact with the mercury, and is a nearly saturated solution of common salt. The upper one contains the anodes, and is a less concentrated solution of the same chemical compound. As no gas is liberated in the lower layer, no difficulty is experienced in maintaining each layer intact. The lower layer thus acts as a diaphragm, and prevents the free chlorine, with which the upper layer of the electrolyte is saturated, from attacking the mercury at the bottom of the cell. Both solutions are regenerated by circulating them through the cell horizontally in the same direction as the mercury.

J. B. C. K.

1759. *Treatment of Gold-Silver Alloys.* **A. Dietzel.** (Zeitschr. Elektrochem. 6. pp. 81–85, July 27, 1899.)—The simplest electrolytic method for treatment of these alloys is to use the alloy as anode in an electrolyte of acidified silver nitrate solution. The silver passes into solution and is redeposited at the kathode, while the gold remains insoluble. The procedure is unsatisfactory when other metals are present as impurities, for part of the acid anion's arriving at the surface of the anode attack and dissolve these impurities, and the composition of the electrolyte thus undergoes gradual change. When copper is present there is also the danger that it may be deposited with the silver at the kathode. This is especially the case with poor gold-silver alloys which always contain considerable amounts of copper. For such alloys the author recommends a method of procedure which has been in successful operation for six years at the "Gold and Silver Scheide Anstalt," at Pforzheim.

The alloys used at this factory are cuttings from various sources, and they average 5–7 per cent. gold, 22–50 per cent. silver, 40–65 per cent. copper, 5 per cent. zinc, tin, and lead; traces of cadmium, iron, nickel, and platinum are also present. The amount reworked daily is about 60 kgs. A copper nitrate solution is used as the electrolyte. The copper and silver pass into solution. The copper is deposited electrolytically; the silver is removed at a later stage *outside the depositing bath* by chemical means. The method is thus a reversal of the usual procedure. The apparatus used at Pforzheim is described and illustrated.

The electrolyte requires to be maintained acid by additions of nitric acid. The removal of the silver is effected in special cylinders filled with scrap copper, which displaces the silver by simple chemical substitution. The silver in solution can be reduced to 0·03 per cent. by this means. Arrangements for the removal of the iron by aëration and filtration are also made.

The insoluble sludge contains gold, silver, copper, tin, and lead, and is treated by chemical methods for the recovery of the gold. The value of the copper deposited in the electrolytic vat under favourable working conditions covers the whole cost of the process. Zinc and cadmium when present pass into solution with the copper and silver, and as these two impurities cannot be removed economically, the electrolyte in time becomes surcharged with impurities and has to be discarded. J. B. C. K.

1760. *Electrolytic Chlorate Works at Chedde, Savoy.* **J. B. C. Kershaw.** (Elect. Rev. N.Y. 35. pp. 8–9, July 5, 1899.)—The process, at work in the factory built by the *Société des Forces Motives de l'Arve*, is that patented by P. Corbin. The works themselves are situated at Chedde Haute Savoie, close to Mont Blanc. The total length of pipe line and tunnel between the dam of the river and the turbines at the works is 1,790 metres. The total available power is 12,000 HP., and to utilise this there are twelve vertical turbines of 1,000 HP., each direct coupled to an Oerlikon dynamo of 830 units. The cells employed according to the Corbin patents are built of cement, and the electrolysis is conducted by means of a number of secondary platinum foil electrodes, insulated from one another in ebonite frames. The current is only introduced at the extreme ends. Reference is made to recent investigations into the chemistry of the Electrolytic Chlorate process, the work of Oettel being specially noted. The author finally enters into the question of the cost of production of the chlorate by the electrolytic method and calculates the price to be 5·59 cents per pound, on an output of 800 tons per annum. J. L. F. V.

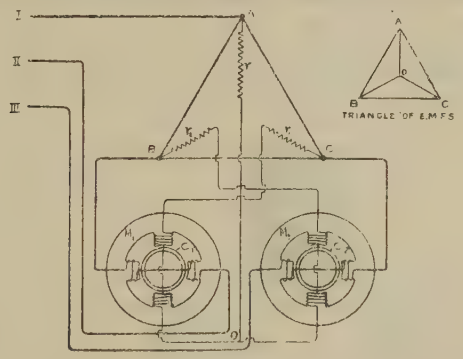
GENERAL ELECTRICAL ENGINEERING.

1761. *Accumulators for Automobiles.* **M. L. Inman.** (Elect. Rev. 45. pp. 119–120, July 21, 1899.)—This article, which is taken from the Revue de Physique et Chimie, gives particulars of the construction of various French makes of storage cells in present use, and more especially intended for traction purposes. Useful figures relative to the electrical capabilities of each type are also supplied. E. J. W.

1762. *New Method of Accumulator Construction.* **A. Tribelhorn.** (Elektrotechn. Ztschr. 20. p. 336, 1899.)—The method resembles that used in the original Volta pile, the cells being piled one above the other instead of being contained in separate glass boxes as is now usual. The battery consists of a series of shallow rectangular lead vessels with sloping sides, placed one above the other, with spherical insulators in the four corners of each vessel to prevent metallic contact. The bottom of each vessel is corrugated, the number of corrugations depending on the number of plates to be used in each cell. From the crests of the corrugations project inwards the negative plates, while the positive plates are suspended from the lower or outer face of the corrugated bottom. When the vessels are in position the downwardly projecting positives of any cell come between the upwardly projecting negatives of the vessel immediately below it. The vessels being shallow, the depth of the electrodes is comparatively small, hence the danger of buckling and short-circuiting is greatly reduced, and the fact that the cells cannot be readily inspected is not a serious disadvantage. The main advantages claimed by the author are: (1) a saving of floor space amounting to as much as 75 per cent. over the ordinary method; (2) there are no joints to be made between the terminals of consecutive cells; (3) absence of special containing vessels or boxes for the plates and acid, and better insulation. A. H.

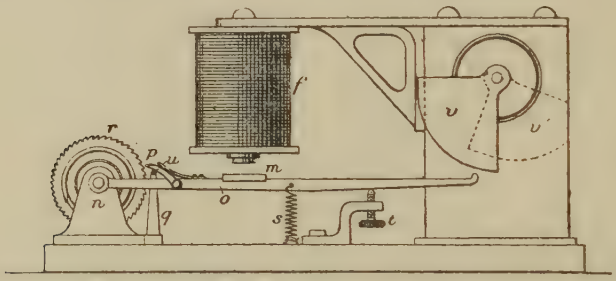
1763. *Safety Devices in Electrical Distribution.* **W. L. R. Emmet.** (West. Electn. 24. pp. 312–313, June 3, 1899. Paper read before the National Electric Light Association, at New York, May 23–25, 1899.)—The author discusses the chief sources of danger and the corresponding safeguards in electrical distribution, with special reference to earth connections, accidental and precautionary. Drawings are given of fusible and other cut-outs intended for breaking heavy currents at extra high pressures with safety. A. H. A.

1764. *Three-Phase Energy Meters.* (Elekt. Runds. 16. pp. 152–154, 1899.)—These meters, recently patented by Siemens and Halske, are of the induction motor type. The principle of construction will be understood from the accompanying figure, which shows the method of connection to a three-phase network. The meter consists essentially of two coupled two-phase induction motors, M_1 and M_2. Each motor has a stator consisting of a hollow laminated cylindrical mass of soft iron furnished with four inwardly projecting pole-pieces, and a central laminated cylinder placed between the pole-pieces. The rotor is a hollow cylinder (C_1 and C_2 in the sketch) of copper or other metal. One pair of diametrically opposite pole-pieces in each stator is provided with a thick-wire or series winding, the other with a fine-wire or shunt



winding. Each fine-wire circuit is rendered practically non-inductive by connecting in series with it a sufficiently high non-inductive resistance (r_1 and r_2 in the sketch). The series windings are inserted into the mains II, III, while the main I is connected direct to the point A of the three-phase load A B C. If for a moment we suppose that M_1 and M_2 are two watt-meters, then in order to measure the power it would be necessary to connect the shunt circuit of M_1 between B and A and that of M_2 between C and A—this being the ordinary two watt-meter method of power measurement. But, since we are dealing with induction motors, the E.M.Fs. between B and A, and C and A, must be replaced by others which are exactly in quadrature with them, in order that the necessary rotating field may be produced. Such E.M.Fs. may be obtained by arranging the connections as shown in the sketch, the resistance r being equal to the total resistance of the shunt circuit of either motor. From the subjoined triangle of E.M.Fs. it is evident that the E.M.F. CO, which acts on the shunt circuit of M_1, is in quadrature with AB, and that similarly BO is in quadrature with CA. A. H.

1765. *Routin's and other Systems of Charging for Electrical Energy.* **E. Hospitalier.** (Ind. Élect. 8. pp. 233–237, June 10, 1899.)—The author applies the laws of supply and demand to show that a fixed rate of charge is wrong in principle, and that the charge should vary in accordance with the demand at any instant. He then reviews all the better-known systems of charging, pointing out their defects, and selects the automatic two-rate meter and the variable charge system of C. E. L. Brown and J. L. Routin as the most approximate solutions of the problem. The former is too complicated, and is limited to two rates; the latter is put forward as the most satisfactory. The system consists of an intermittently integrating watt-meter or ampere-meter, the frequency of integration of which is controlled from the generating station, and varied according to the demand. In the figure, *v* is a cam whose position is controlled by the mechanism of the watt-meter; the lever *o* bears an armature *m* which is attracted by the electromagnet *f*, and rotates the ratchet-wheel *r* (connected with the recording train) by means of the



pawl *p* round the axis *n* through an angle proportional to the power passing, its range being dependent upon the position of the cam *v*. The lever is restored by the spring *s* to its initial position, which is adjusted by the screw *c*. The conical screw *u* provides an additional adjustment for the pawl. The whole of the meters on consumers' premises are controlled by a master-clock at the generating station, which actuates the electromagnets by momentary currents; the frequency of these currents is regulated to suit the demand, either in steps or by a gradual variation. To avoid the necessity of special wires, when the supply is on the direct-current system, alternating currents are periodically transmitted to the meters, using one of the line conductors with earth return through a condenser; while, if an alternate current supply is used, direct currents are transmitted, the condenser being omitted and the inductance of the electromagnets being made so great as to choke back the alternating currents. A special wire is, however, necessary if a high pressure system with isolated transformers is used. The advantages claimed for the system are: simplicity, complete control of the variable rate of charging, absence of auxiliary wires, direct

indication of the sum payable, and small consumption of power in the meters. The system is no bar to the installation of numerous and varied apparatus, while it affords the most rational and just means of charging for energy. — A. H. A.

1766. *Ampere-Hour Meter without Jewels.* **W. D. White.** (Elect. World and Engineer 33. pp. 855–856, June 17, 1899.)—W. Stanley suspends the aluminium brake disk by the magnetic attraction of the permanent field magnets. The instrument can be used as calibrated in the factory and travels without any part requiring to be clamped. — M. O'G.

1767. *Determination of Starting and Braking Resistances for Traction Motors.* **F. Erens.** (Elektrotechn. Ztschr. 20. pp. 277–282, 1899.)—In order to secure as constant an acceleration as possible, the starting-current must not be allowed to vary outside certain limits. The upper limit, $I_{max.}$, depends (1) on the greatest current which the motor can stand with safety; (2) on the point at which slipping of the car wheels occurs. Where secondary cells are used, $I_{max.}$ is further limited by the maximum discharge rate of the cells. The mean value of the starting current depends on the time during which the car is required to attain full speed; when this is given, the corresponding torque and current may be determined. The maximum and mean values of the starting current having been thus found, its minimum value, $I_{min.}$, is also fixed. The value of $I_{min.}$ is, however, further restricted by the fact that if the difference $I_{max.} - I_{min.}$ be made very small, a very large number of contacts will be required in the controller; if the number of contracts is fixed, as well as $I_{max.}$, then $I_{min.}$ is (as will be evident from what follows) also fixed. The counter-E.M.F. e of the motor is a function of the car speed and the current, so that $e = ksm$, where k is a constant depending on the gearing and wheel diameter, s is the speed of the car, and m a factor whose value depends on the current. If V be the working P.D. of the line, and R the total resistance in the motor circuit, the corresponding current is given by—

$$I = \frac{V - ksm}{R} \quad . \quad . \quad . \quad (1)$$

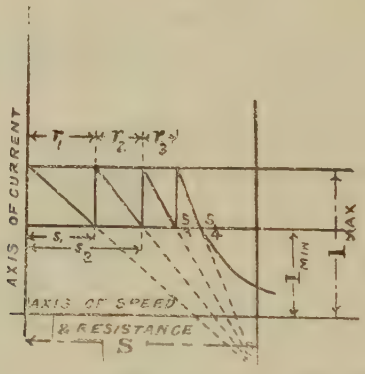
Let m_0 and m^1 be the values of m corresponding to $I_{max.}$ and $I_{min.}$ respectively; further, let $\alpha = I_{min.}/I_{max.}$, and $\beta = m^0/m^1$. Then, by successive application of the fundamental equation (1), the author shows that, if s_1, s_2, . . . stand for the speeds attained by the car as the controller-handle passes over the successive contacts,

$$s_2 - s_1 = \alpha\beta s_1 \; ; \; s_3 - s_2 = (\alpha\beta)^2 s_1 \; ; \; s_4 - s_3 = (\alpha\beta)^3 s_1, \text{ &c. } . \; . \; . \quad (2)$$

Also, if r_1, r_2, r_3, . . . stand for the consecutive resistances which are cut out as the controller-handle is turned, then

$$r_2=\alpha\beta r_1\,;\; r_3=(\alpha\beta)^2 r_1\,;\; r_4=(\alpha\beta)^3 r_1, \text{ \&c. . . .} \qquad (3)$$

Since equations (2) and (3) are of the same form, it follows that if in a graphical construction s_1, s_2-s_1, s_3-s_2, . . . be represented by certain lines, these lines will also, to a different scale, represent r_1, r_2, . . . The graphical construction given by the author is shown in the accompanying figure, in which S stands for the sum to infinity of $s_1+\alpha\beta s_1+(\alpha\beta)^2 s_1+$ . . . and denotes the theoretical speed which would be reached with a current $I_{min.}$ if the controller were furnished with an infinite number of contacts and the resistance of the motor were negligible.



The author next extends his analytical investigation and graphical construction to the case of a shunt-wound motor, and to the determination of the resistances to be inserted into the motor circuit when utilising its generator action for braking purposes.

A. H.

1768. *Aluminium Conductors.* J. B. C. Kershaw. (Lightning, 16. pp. 27–28, 143–144, 1899.)—Notes upon the practical applications of aluminium as an electrical conductor. (See 1899, Abstract No. 164.) EDITOR.

1769. *Mechanical Applications of Electricity.* G. Richard. (Écl. Électr. 19. pp. 481–489, July 1, 1899, 20. pp. 81–89, July 22nd.)—Descriptions of mechanical appliances including Tesla's marine mechanisms controlled by waves, Eickemeyer pump, various weighing machines, clocks and fans. EDITOR.

1770. *Electric Motor Semaphore.* **F. Křižik.** (Zeitschr. Elektrotechn. Wien, 17. pp. 392–398, July 16, 1899.)—It is proposed to work railway signals and other semaphores by means of electromotors. The arm of each semaphore is to be connected through a system of levers to an eccentric gear actuated by an electromotor. Diagrams are given showing the electrical connections necessary for a "block" signal arrangement. The method has only been tried in the form of a model. R. A.

1771. *Electric Power for Marine Propulsion.* **C. T. Child.** (Eng. Mag. 17. pp. 477–482, June, 1899.)—The author points out that, except in the case of canal boats, the electric propulsion of vessels must be by means of secondary batteries, and briefly discusses their characteristics. The great weight and small capacity of accumulators are far less detrimental afloat than in vehicles on roads; under the best conditions—when the battery is discharged in one hour—the weight of an electrical equipment is about 234 lb. per H.P., as compared with 57·5 lb. in the case of a steam outfit. The author considers that a frequent service of ferry-boats, for example, equipped with electrical machinery, and charged from a shore-station each trip, would show a high efficiency combined with other advantages. Torpedo boats are also instanced as peculiarly suited to electric propulsion; such a boat could attain a speed of 22 knots for one hour, or 12 knots for twenty-four hours with the same battery. A. H. A.

1772. *Electric Pumping in Mines.* (Elect. Rev. 44. pp. 939–941, June 9, 1899.)—This paper consists, principally, of a description of some of the electrical pumps supplied by Messrs. Scott & Mountain; *e.g.*, a combined centrifugal pump and motor, and a combination of triple-pump and electric-motor designed to run in any position where there is much dust or dirt. In the latter combination the motors develop about 2 H.P. each and run at 1,223 revs. per minute, the power being transmitted to the pumps by means of spur and worm gearing, the steel worm revolving in an oil-bath. A. S.

1773. *Condensers for Electric Light and Power Stations.* **J. F. C. Snell.** (Electrician, 43. pp. 406–408, July 14, 1899. Discussion, pp. 408–409. A paper read before the Municipal Electrical Association, June 16, 1899.)—Surface condensers, ejector condensers and evaporative condensers are discussed with special reference to the working conditions. A discussion followed. A. S.

GENERATORS, MOTORS, AND TRANSFORMERS.

1774. *Synchronisers for Three-Phase Generators.* **H. Müller.** (Elektrotechn. Ztschr. 20. pp. 416–417, June 15, 1899.)—Several devices are described capable, not only of indicating when the alternators are in phase, but also of showing whether the incoming machine has to be accelerated or retarded in order to run synchronously. The first device consists of two simple laminated rings, one within the other, the outer being fixed and the inner free to rotate, and carrying an index. Both rings are provided with an ordinary Gramme winding; three points 120° apart in the winding of the outer ring are connected to the three-phase 'bus bars, and the winding of the inner ring is similarly connected to the terminals of the incoming machine. The connections are so arranged that the rotating fields in the two rings have the *same* direction of rotation. It is obvious that if the incoming machine is running synchronously and co-phasally, no torque will be exerted on the movable ring, which will also occupy a perfectly definite position (the index being vertical). But if the machine is either fast or slow, there will be relative rotation of the two fields, which will be rendered visible by a rotation of the inner ring. The main switch is closed at the instant when the index slowly passes through the vertical position. In another device, somewhat simpler in construction, a single fixed laminated ring provided with three independent closed windings is used. The first winding is connected to the 'bus bars, the second to the terminals of the incoming machine, and the third supplies a number of incandescent lamps arranged in a circle, diametrically opposite lamps being joined in series with each other and connected to diametrically opposite points in the winding. The fields due to the first and second windings are arranged to rotate oppositely. If the incoming machine runs synchronously, a simple alternating field will be produced in the ring, and in the circle of lamps there will be one pair (diametrically opposite) at maximum brilliancy, the brilliancy of the others falling off round the circle until complete darkness is reached along the extremities of a perpendicular diameter. If further the machine runs co-phasally, the diameter of maximum brightness occupies a perfectly definite (vertical) position. Want of synchronism, and the direction in which the speed should be varied, are indicated by an advancing wave of light in the circle of lamps.

[*Cf.* Abstract No. 892, 1899. The arrangement described above has been used for a number of years by L. Schüler; see Elektrotechn. Ztschr. 20. p. 523, 1899.] A. H.

1775. *Friction Losses in Dynamos.* **G. Dettmar.** (Elektrotechn. Ztschr. 20. pp. 380–383, June 1, and 397–400, June 8, 1899.)—The author's experimental investigations lead to the following important results: 1. When the bearings are maintained at a constant temperature, the coefficient of friction increases as the square root of the speed, so that the *power lost by friction increases as the* 1·5*th power of the speed.* 2. The bearings being maintained at a constant temperature, and the speed remaining constant, the coefficient of friction varies inversely as the pressure per sq. inch of the bearings, so that *the power lost by friction is independent of the pressure on the bearings*, provided the latter does not exceed 30 to 44 (depending on lubricant) kg. per sq. cm. (426 to 624 lb. per sq. inch), which is well outside the limits of good practice. 3. The pressure on the bearings and the speed being constant, the coefficient of friction, and *power lost by friction, vary inversely as the temperature* (in degrees C.; between limits of 15° and 50° C.). Results 1 and 2 are also borne out by some experiments on friction carried out by Tower in 1885 (Ztschr. Ver. Deutsch. Ing. pp. 839–840). The author arrived at result 1 by experimenting on a countershaft supported by three bearings and carrying no pulleys, but only a speed cone whose greatest diameter did not exceed 29·5 cm. With such an arrangement, windage is negligible in comparison with bearing friction; and since result 1 was found to hold for this case, it follows that the increase in the frictional resisting torque with increase of speed is, in the case of dynamos, to be ascribed to a true increase in the coefficient of friction, and not, as one might at first feel inclined to suppose, to increased air resistance. The countershaft experimented on was run up to the desired speed by means of an electromotor which was directly coupled to it, and the method of ascertaining the power absorbed by the shaft at different speeds consisted of a combination of the method explained in Abstract No. 199 (1898), with that explained in Abstract No. 1430 (1899). Some special experiments, carried out by the author with the view of ascertaining the relative amount of frictional loss due to windage, lead to the conclusion that in dynamos with rotating armatures, this loss does not exceed from 7 to 9 per cent. of the total friction loss. The method of experimenting consisted in running a motor carrying a flywheel having a heavy rim supported by arms, first under ordinary conditions, then with a plain cylindrical case slipped over the flywheel, so as to reduce the churning action as much as possible. Result 2 is equivalent to the somewhat startling assertion that the *friction loss remains constant at all loads, and is independent of the tension of the belt.* The truth of this statement is, however, borne out by an experiment in which the frictional losses were determined for a 2 H.P. motor when running with and without a heavy flywheel, whose weight was sufficient to double the pressure on the bearings: absolutely no difference between the friction losses corresponding to the same speed could be detected in the two cases. On the basis of these

results, the author establishes some useful formulæ for calculating the frictional loss. The most important of these are given below :—

$$F_1 = 49r.d.l.v^{1\cdot5} \quad . \quad . \quad . \quad (I)$$

$$F_2 = \frac{-T + \sqrt{T^2 + 62\cdot4u.s.v^{1\cdot5}}}{0\cdot637u}.d.l \quad . \quad . \quad . \quad (II)$$

In the above, F_1 and F_2 stand for the friction loss in watts; d is the diameter, and l the length of journal, in cm.; v is its peripheral velocity, in *metres per second*; and r, u, and s denote certain constants to be determined for each type of machine. The simpler formula (I) does not, and the more complicated one (II) does, take into account temperature changes. For the machines built by Körting Bros., the author found that the constant r had a value of ·014 at a temperature of 37·5° C.; and the constants u and s values of 25 and 0·53 respectively. In formula (II), T is the temperature of the surroundings, and may be taken to be 20° C. The friction losses calculated by the above formulæ were found to agree very satisfactorily with those determined by experiment. A. H.

1776. *Friction Losses in Dynamos.* **J. Fischer-Hinnen.** (Elektrotechn. Ztschr. 20. pp. 392–393, June 1, 1899.)—The author finds that for carefully constructed machines the coefficient of friction varies between 0·038 and 0·06 with a peripheral velocity of the journal amounting to from 2 to 2·5 metres per second. Dealing next with brush friction, he gives the following formula for the loss in watts W_b due to this cause :—

$$W_b = \frac{2\rho}{S} \cdot \frac{I^2}{p} + 2 \times 9\cdot81SPfv.$$

where—

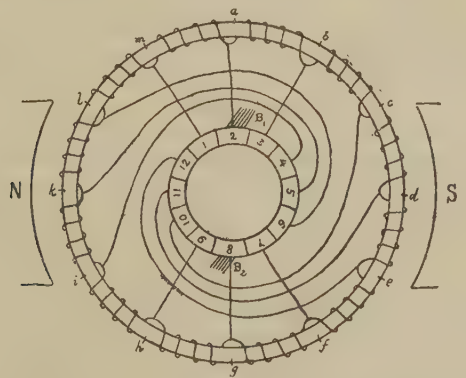
ρ = contact resistivity (= 0·2 for carbon, and 0·02 for metal brushes).
S = brush contact area per rod, in sq. cm.
I = total armature current.
p = number of bifurcations of armature current.
P = brush pressure, in kilogrammes per sq. cm. (= 0·12 to 0·15).
f = coefficient of friction (= 0·3 to 0·4).
v = peripheral velocity of commutator, in metres per second.

By differentiating W_b with respect to S and equating to zero, we obtain S_o, the value of S which gives a minimum value of W_b. We thus get $S_o = \frac{0\cdot21I}{p\sqrt{v}}$ for metal brushes, and $S_o = \frac{0\cdot68I}{p\sqrt{v}}$ for carbon brushes. In the case of machines of moderate size

(20 to 60 kilowatts) working at 100 to 120 volts and having two to four brushes, it is not always easy to provide the contact area demanded by these formulæ. A. H.

1777. *Improvements in Brush Alternators.* **E. K. Scott.** (Electrician, 43. pp. 595–596, August 18, 1899.)—The paper describes the reconstruction of the brush alternators at Bankside station by Ferranti Ltd. The main improvements consist in using copper strip beaded down the middle for winding the armature coils, whereby side slip is absolutely prevented; in connecting all the coils in series instead of two parallels, thus dispensing with an equaliser, the coils with maximum voltage between them being separated by a dummy coil; and in drilling the pole-pieces and fitting them with external cowls which serve to catch the air and drive it against the armature coils through the perforations in the pole-pieces. A. H.

1778. *Special Types of Alternators.* **F. J. Patten.** (Elect. World and Engineer, 33. pp. 648–649, 1899.)—A brief illustrated description of some methods of obtaining alternating and pulsating unidirectional currents from an ordinary Gramme armature. The arrangement shown in the accompanying sketch is one patented by the author in 1889. The points *m*, *a*, and *b* in the winding



are connected to the nearest commutator segments; the next group of points, *c*, *d*, *e*, is in connection with diametrically opposite segments; and so on alternately. Such an arrangement gives two complete waves of alternating current per revolution in an external circuit connected between the brushes B_1 and B_2. A pulsating unidirectional current may be obtained in a circuit by

connecting one of its terminals to one of the ordinary brushes of a simple Gramme armature (with ordinary connections to commutator), and the second terminal to a brush pressing against a slip-ring which is joined to one point in the winding; a single pulsation corresponds in this case to a revolution. By arranging a second circuit between the same ordinary brush and a second slip-ring connected to a point diametrically opposite to the one in connection with the first ring, a pulsating current having the reverse direction will be obtained in the second circuit. A. H.

1779. *Westinghouse Alternators at Madison Electricity Works, N.Y.* (Amer. Electn. 11. pp. 257–259, June, 1899.)—A Westinghouse alternator of a new type has lately been installed in this station. The machine is rated at 250 kw. and delivers single phase current at 1,100 volts; the armature winding, instead of being one coil per pole buried in a large slot, as in the usual type, consists of a spiral coil for each pole fitting into eight slots, these slots are almost uniformly spaced round the surface of the armature, the middle tooth of each group being slightly wider than the rest; the coils are kept in position by wooden strips as in the direct current machines of the same company. Another peculiarity is that the armature current itself does not pass through the rectifying commutator and series coils of the field; a series transformer rotates with the armature and supplies the commutator and series field with a derived current proportional to the armature current going to the collector; the transformer is divided into two parts placed diametrically opposite to each other to preserve balance. M. G. W.

1780. *Measurement of Slip of Induction Motors.* **E. Rosenberg.** (Zeitschr. Elektrotechn. Wien, 17. pp. 327–331, June 14, 1899.)—The slip of induction motors with wound rotors connected to slip-rings is measured by joining in parallel with one of the cables leading from the brushes to the starting resistance an induction coil and telephone, and thus counting the frequency of the rotor currents by ear. For squirrel-cage rotors the leakage-field due to the rotor current is employed by means of an induction coil and telephone. The necessary precautions are detailed. To obtain a permanent record of the slip the induced currents are made to actuate the relay of a Morse writing telegraph instrument, and thus a rapidly varying slip up to 20 per cent. can be accurately determined at any instant. A complete investigation made by this method is described. The motor employed was a $3\frac{1}{2}$ HP 42 $\sim$ four-pole induction motor, and observations were made at various loads as motor, and also

when driven at over-synchronous speeds as generator. Some of the results are given in the following table:—

AS MOTOR.

Slip ∼ per min.	Speed Revs. per min.	Input. Volts.	Amps.	Watts.	Output. H.P.	Watts.	Torque kg. m.	Power factor cos ϕ.	Effy. per cent.
36	1,282	104	27	870	0·57	420	0·32	·31	48
66	1,267	105	37	2,540	2·53	1,864	1·43	·66	70
86	1,257	104	45	3,380	3·45	2,542	1·98	·73	75
120	1,240	102	56·5	4,400	4·10	3,022	2·37	·77	71
186	1,207	101	68	...	4·55	3,361	2·72	...	...
366	1,117	100	88	...	4·2	3,104	2·72	...	...

AS GENERATOR.

		Ouput.			Input.				
16	1,308	110	27·5	...	1·00	733	0.55	...	...
58	1,329	113·5	41·5	2,360	4·68	3,439	2·52	·50	69
82	1,341	113·5	50	3,240	6·10	4,489	3.27	·57	72
100	1,350	114·5	60	3,990	7·45	5,485	3·96	·58	74

(See also 1899, Abstract No. 1579.)

L. B.

1781. *Theory of Induction Motors.* **G. Ossanna.** (Zeitschr. Elektrotechn. Wien. 17. pp. 223–228, 236–240, and 248–255, 1899.)—Starting from a simple vector diagram which gives the magnitudes and phases of the various quantities involved, the author obtains expressions for the primary current, torque, heat loss in conductors, slip and efficiency, and from them deduces graphical representations of the variations of these quantities with secondary load. A number of numerical examples are worked out. A. H.

1782. *Transformer Cores.* **E. K. Scott.** (Electrician, 43. p. 192, June 2, 1899.)—The author states that, quite apart from magnetic ageing, the large core loss observable in some types of transformers is due to excessive mechanical pressure on the core plates, which are screwed up very tightly between end plates. He cites a case noticed by Mordey in which a laminated core when subjected to a pressure of 1,500 lb. per square inch gave an increase of 21 per cent. in the core loss (the latter returning to its original value on removal of pressure). In another case, recorded by Parshall, a pressure of 2,200 lb. per square inch on

a good sample of transformer iron increased the hysteresis loss by 53 per cent. These experiments appear to show that in building up transformer cores only so much pressure should be exerted on the core plates as is absolutely essential to good mechanical construction. A. H.

1783. *Transformer Core Losses.* **W. E. Goldsborough.** (Elect. World and Engineer, 33. pp. 645–647, 1899.)—Curves and tables are given showing the great progress recently made in transformer construction. In the older types of 125-cycle transformers the average core losses amount to from 1 per cent. to 9·7 per cent. for outputs ranging from 20 kilowatts to 1 kilowatt respectively. In modern transformers of the same frequency and range of output the average core losses vary between the narrow limits of ·8 and 2·6 per cent. The improvement is even more marked in the case of 60-cycle transformers, the corresponding figures being 1·4 to 11·3 per cent. for the older types, and 1·1 to 3 per cent for the modern ones. A. H.

1784. *Transformer Tests.* **W. E. Goldsborough.** (Eng. News, 40. pp. 351–353, June 1, 1899. Also Elect. World and Engineer, 33. pp. 875–876, June 24th. See 1899, Abstract No. 190.)—The following results were obtained with five 5-kilowatt 60-cycle modern transformers by different makers :—

	I.	II.	III.	IV.	V.
Regulation, hot, per cent.	1·74	2·63	2·16	2·32	2·12
Iron loss, full load, per cent.	1·63	1·41	1·76	1·42	1·71
Copper loss (hot), full load, per cent. ...	1·78	2·51	2·07	2·05	2·04
Efficiency, per cent., at ·1 output ...	85·4	87	84·2	87·4	84·7
„ „ „ ·25 „ ...	93·3	93·9	92·7	94·1	92·9
„ „ „ ·5 „ ...	96·0	95·9	95·4	96·2	95·6
„ „ „ ·75 „ ...	96·5	96·2	96·1	96·6	96·2
„ „ „ full output ...	96·6	96·1	96·2	96·6	96·3
„ „ „ 25 % overload ...	96·5	95·7	96·0	96·4	96·2
Temperature above air, full load test, degrees C. ... After 5 hrs.	20·6	20·3	41·7	23·7	39·9
„ „ 10 „	24·9	27·1	52·1	30·6	49·9

Tests made to determine the ageing of the cores showed that the iron was, in all five transformers, practically of non-ageing quality.

In the discussion on the above paper, **Leslie** stated that his company required a 2 per cent. regulation with a 2 per cent. core loss and an insulation resistance of not less than 2,000 megohms. His experience was that the life of even a modern transformer did not much exceed five years. **Robb** considered that the data given by Goldsborough were applicable to lighting transformers only. A. H.

1785. *Transformer Core Losses.* **G. W. Hubley.** (Elect. Rev. N.Y. 34. p. 382, June 14, 1899. Abstract of a paper read before the National Electric Light Association, N.Y., May 25, 1899.)—The author gives the following table, which relates to transformers of various types of manufacture during the years 1894–96, and which shows the very considerable gradual increase in the core loss :—

Capacity of Transformer, in Kilowatts.		·5	1·0	1·5	2	3	4	5	7·5	10	12·5	25
Core loss in watts	Initial test	36	58	60	75	80	109	120	145	190	218	323
	Second test	65	75	97	125	133	175	140	167	250	238	530
	Third test	75	100	120	145	150	185	145	190	...	315	...

The time of service between tests in the above table varies from six months to two years, but in most cases it is one year. In order to reduce the abnormal core losses exhibited by some transformers, the author has recently adopted the plan of re-annealing the core-plates. The effect of this treatment is shown by the following table :—

Capacity of Transformer, in Kilowatts.		·5	1	2	3	7·5	10	25
Core loss in watts	Initial test.....	40	60	84	108	140	175	350
	Test before treatment	64	88	150	139	167	240	530
	Test after treatment	42	59	117	97	135	160	323

The author finds that the cost of reannealing is trifling in comparison with the increased economy of working which is thereby secured. A. H.

1786. *Design of Single-Phase Rectifier.* **J. C. Brocksmith.** (Amer. Electn. 11. pp. 282–285, June, 1899.)—A detailed description, with full working drawings, of a single-phase rectifier, suitable for 50 or 100 volt circuits and a frequency of 60 or 125. A. H.

1787. *High-Speed Rotary Converters.* **E. K. Scott.** (Electrician, 43. pp. 304–305, June 23, 1899.)—The author gives diagrams showing that the price and weight of continuous current transformers, as at present designed, are respectively five and three times as great as those of alternating current transformers of equal rating, and suggests that they should be run with spindles vertical

at about four times the ordinary speed. A cross-sectional elevation of such a transformer is given; it is pointed out that the floor-space occupied is very small, and that the machine could be lowered through a small manhole into an underground substation. To relieve the pressure of the footstep bearing, the armature core may be placed slightly out of centre vertically. The same arguments apply to boosters, balancers, &c. A. H. A.

1788. *Transformation of Three-Phase to Two-Phase Currents.* **P. G. Watmough.** (Elect. World and Engineer, 34. pp. 120–121, July 22, 1899.)—The author explains the principle of this transformation in a very simple manner as follows: Draw three equal vectors, A, B, and C, 120° apart, to represent the three E.M.Fs. of the three-phase supply. Reverse C, and then compound it with B. Increase the length of A in the ratio of 1·73 : 1. Then the resultant of B and C reversed on the one hand, and A lengthened on the other, constitute a pair of equal vectors in quadrature, and thus represent two-phase E.M.Fs. In practice, these changes may be carried out by using two transformers; the primary of the first is supplied with the A – E.M.F.; by using the proper number of turns in the secondary, this E.M.F. may be increased in the required ratio. The second transformer is provided with two primaries, one supplied with the E.M.F. B, the other with the E.M.F. C; reversal of the latter is obtained by reversing the connections of the corresponding primary coil; and compounding of B and C reversed results if a single secondary be provided. The secondaries of the transformers will thus supply two-phase currents. A. H.

POWER DISTRIBUTION, TRACTION, AND LIGHTING.

1789. *Distribution by Two-Phase Currents in New York, U.S.A.* **E. A. Leslie.** (West. Electn. 24. pp. 311 and 317, June 3, 1899. Paper read before the National Electric Light Association at New York, May 23–25, 1899.)—A description is given of the methods and apparatus adopted in substituting two-phase for single-phase distribution, in order to supply motors above 5 H.P. On account of want of facilities in the common subways, two separate circuits are used, in quadrature, instead of a common return system. A novel system of regulation, devised by W. F. Wells, is described and illustrated; a third wire is connected with the armature winding of each phase, at a point 10 per cent. from one end, so that there are six 'bus bars in all. Between the two 'bus bars in each phase which thus differ in potential by 10 per cent. of the whole pressure, a "single-wound transformer" is connected for each external circuit; the winding of this is divided into ten parts joined to a regulating switch. The circuit wires are joined, one to the switch and one to the remaining 'bus bar. With this apparatus the pressure can be regulated in steps of 1 per cent. of the total pressure. The system of testing the insulation of the live circuits and of locating faults is described, with diagrams; when overhauling and testing the circuits, the testing galvanometer is fixed in the station, and communication is maintained with the repair gang by means of telephones temporarily connected with the main cables. The system of two-phase distribution used by another New York supply company is also briefly described; in this case the generators and some of the transformers are connected on the "star" system, with three-wire feeders, one of which is smaller than the others and is used for power only. The power required in New York for elevators alone amounts to 15,000 H.P. A. H. A.

1790. *Three-Phase Four-Wire Low-Tension System.* **A. J. Bowie.** (Elect. World and Engineer, 33. pp. 840–842, June 17, 1899.)—The system considered is one in which star-coupled generators supply a four-wire distributing network, the fourth wire being in connection with the neutral point. The P.D. between the neutral and any one of the three "legs" is 115 volts, and is intended for lamps, while that between any two legs is 200 volts, and is intended for motors. The author compares this system with (1) the continuous-current three-wire system; (2) the transformer system. 1. Good balance and large mains are more important with the alternating system, which is likewise harder to balance, as the load must be divided into three parts instead of

two. All troubles from inductance and low power-factor are absent with the continuous-current system. Allowing for a high power-factor, the efficiency of the two systems would be about the same. The drop is greater in the alternating system, thus requiring more switchboard attendance. 2. The full-load efficiency will generally be in favour of the transformer system, which also has the advantage that so good a balance is unnecessary, and that a sudden change in the load, even if it occur on one leg only, will not affect the P.D. as much as in the other system. A load with a low power-factor, does not make nearly so much difference with the transformer system, by reason of the very much smaller primary drop. In conclusion, the author regards it as doubtful whether a low-tension four-wire three-phase system will ever pay so long as 115-volt lamps are used—a transformer system being generally preferable. But if high-voltage lamps should improve in efficiency, he regards it as probable that the system considered will have a large field of usefulness.

A. H.

1791. *Problems in Long Transmission Lines.* **F. Breisig.** (Elektrotechn. Ztschr. 20. pp. 383–386, June 1st; 400–403, June 8th; and 417–420, June 15, 1899.)—An elaborate mathematical paper, in which the author develops graphical constructions for the various problems presented by a long power transmission line. The fundamental problem is that in which the P.D., current and phase difference at the far end of the line are given; and it is required to determine the phase difference and find the magnitudes of the P.D. and current at the transmitting end, the resistance, inductance, leakage, and capacity of the line all being taken into consideration. The author devotes a good deal of attention to the question of efficiency, and arrives at the important conclusion that the use of P.Ds. exceeding 15,000 volts would not, in general, much increase the efficiency of transmission, except in the case of very large powers. A. H.

1792. *Underground Mains.* **L. A. Ferguson.** (Elect. World and Engineer, 33. p. 877, June 24th, and 34. pp. 11–13, July 1, 1899. Abstract of a paper read before the National Electric Light Association of New York.)—The various systems of cable laying employed in America are described with tables of costs. In the Edison tube system, copper rods in 20-feet lengths are covered with jute and drawn one, two, or three as required into iron pipes. The pipes are then run in with asphaltum. The cost of laying mains on this system is analysed and compared with the cost of lead-covered cables. The Edison tube is 25 per cent. to 33 per cent. cheaper in capital outlay, but is more liable to faults. The annual cost of maintenance of the Edison tube,

amounting to 1·91 per cent. of the capital outlay, is fully analysed.

For feeders, most of the large central stations are abandoning the Edison tube in favour of conduit systems on account of their greater reliability. The cost of laying the following systems is analysed for various number of ducts and different classes of paving: the National; the Francis; the Camp Tile; the Lithocite conduits; and iron pipes. The first four cost 7d. to 8d. per duct per foot under wood paving, 9d. to 1s. under granite setts, 7d. to 10d. under macadam, and 1s. to 2s. 4d. under asphalt. Iron pipes are in each case about 6d. per duct per foot more expensive. For jointing, brick manholes are built which should be well ventilated and drained to the sewage system by non-return valves. Feeder cables may be drawn in 130- to 200-yard lengths. The cost of building manholes and repaving is given for various sizes and classes of pavement varying from 2s. in the larger to 8s. 6d. in smaller sizes per cubic foot. Paper insulation for the cables is coming into use instead of rubber owing to its relative cheapness. Under rivers, submarine cables or tunnels are employed.

Overhead systems, even when allowed, are not found advisable in the long run in urban areas. L. B.

1793. *Short Distance Electric Power Distribution.* **J. Swinburne.** (Eng. Mag. 17. pp. 827–832, August, 1899.)—The author points out that electric driving of workshops is often overlooked through thoughtlessness, and gives instances where it is specially suitable, as when the load is variable or divided amongst a number of separate motors. The use of gas engines is briefly dealt with, and the question of electric supply on a large scale. For variation of speed a multiple wire system with different pressures is suggested. The saving in foundations and other items is noticed, as well as the suitability of electric power for the auxiliary machinery on board ship. A. H. A.

1794. *Rotary Transformers and Storage with Long-Distance Transmission at Hartford.* **W. L. Robb.** (Elect. Rev. N.Y. 34. pp. 344–345, 1899. Paper, read before the National Electric Light Association, New York, May 23, 1899.)—The author describes the plant installed at Hartford, which is supplied from a water-power station eleven miles distant. The maximum power available is 1,200 E.H.P., generated by two 600 kw. alternators, and transmitted on the three-phase system at 10,000 volts. There are two auxiliary steam engines at Hartford of 1,600 H.P., driving a 600 kw. alternator and a 400 kw. two-phase rotary transformer as a generator of direct or alternating currents. The arrangement of the three-wire distribution is described, as well as of the storage battery, which has a capacity of 2,500 H.P. hours at a five-hour rate

of discharge. There are two rotaries of 250 kw. each in the battery substation. The battery is charged by varying the ratio of the static transformers. The alternators are always run in parallel, with at least one rotary and the storage battery in connection, so that the whole system is electrically interlocked. The neutral wire of the three-wire system is connected to the middle of the secondaries of the static transformers. No difficulty is found in running the three alternators in parallel, although one is steam-driven and eleven miles from the others. The carbon brushes for the rotaries are plunged at red heat into oil, with great advantage in reducing sparking. Hunting of the rotaries, due to the pulsation of the steam alternator, was entirely cured by attaching copper strips to the pole-pieces of the 400 kw. machine. The plates of the battery are removed when they have lost one-third of their original capacity. Diagrams are given showing clearly the division of load between the rotaries and the battery, and the great advantages of the latter, which also carries the whole load on Sundays. The author strongly recommends the system.

A. H. A.

1795. *Electricity Supply of London.* **A. H. Preece.** (Instit. Civ. Engin. Proc. 134. pp. 5–58, 1899. Discussion, pp. 59–80.)—The author summarises the conditions of supply in the county of London, and gives a table showing the present position of the industry. The average dividend paid in 1897 was 7¼ per cent., and the average costs were 56 per cent. of the revenue.

A typical arrangement of generating works is described, and the methods of working in vogue are discussed at length. It is stated that the boilers in use are divided as follows: Water-tube, 75·5 per cent.; Marine, 11·0 per cent.; Lancashire, 5·5 per cent.; miscellaneous, 8·0 per cent.; while the engines are: high speed, 62·5 per cent.; low speed vertical, 25 per cent.; low speed horizontal 6·25 per cent.; special, 6·25 per cent. Direct-coupling is universal. Details are given of a test made on a steam alternator, showing a consumption of 25·1 lb. steam per kw. hour. Distribution systems are next dealt with, and the methods of charging. The total capital expended per 8 c.p. lamp connected is £2 10s. average for direct current, and £3 for alternating, with extreme values of £1 14s. and £4 4s. The capital per kilowatt installed in works varies between £89 and £242. The percentage values of capital expenditure on different items are given for five stations. The details of costs of supply are examined, and stress is laid on the importance of the load factor, which varies between 10 and 22 per cent. approximately. The generating and distributing costs amount on the average to 1½d. per unit for direct and 2d. for alternating current, while management, &c., cost 1d. per unit; the total cost varies between 2½d. and 3d. per unit with large works. The accounts of the City of London (A.C.) and the

Westminster (D.C.) Companies for 1897 are compared in detail. The paper concludes with an appendix giving detailed descriptions of thirteen London undertakings.

In the discussion numerous points of detail were considered, especially steam losses, vibration nuisances, storage, and load factors. The paper is illustrated with figures and a coloured map of London showing the areas occupied by the various supply undertakers. A. H. A.

1796. *Brooklyn Electric Supply System.* **W. S. Barstow.** (Elect. World and Engineer, 34. pp. 13–16, July 1st; p. 54, July 8th; and pp. 89–90, July 15, 1899. Abstract of a paper read before the National Electric Light Association of New York.)—The system employed is a three-phase 25 ∿ with 6,600 volt distribution from the main station at Bay Ridge to twelve substations. In these it is converted by static transformers, rotary converters, or motor generators, into whichever form is most suitable to the local conditions, one, two, or three phase of various frequencies, or direct current at various pressures. Actual determination of the effect of load factor upon central station costs show that with an 80 per cent. load factor they are 70 per cent. less than with a 25 per cent. load factor and the same output. The system of metering the various outputs and tracing the losses is described. Steam auxiliaries, though not individually so efficient as if electrically driven, may be more economical if their exhaust steam be used to heat the feed water. Both should be installed, and the duty distributed between them according to the load to get maximum economy. In the Bay Bridge station the electric auxiliaries take 50 E.H.P. (=67 I.H.P.) for each 2,732 I.H.P. engine or 2·45 per cent.

The alternators are excited from a dynamo driven by a synchronous motor and paralleled with a small battery. The difficulties of paralleling engine-driven alternators are considered, particularly under the influence of synchronous motors or other inductive load. Both overhead and underground feeders are used. When underground the cables are lead and paper-covered three cores laid in tile ducts. Where liable to electrolysis rubber-covered cables are used, protected with asbestos. Owing to resonance effects the pressure at the far end of the feeders frequently rises momentarily to double that registered at the station. It has been found that low insulation cables are often more durable than those of high insulation resistance. Three-fourths of the substation output is continuous current, 3,800 kw. of rotary converters being installed. They do not give trouble by falling out of step in spite of overloads and short circuits. The alternating current distribution is mainly two-phase 60 ∿. The efficiency of the substation plants as measured by watt-meters are as follows. A 400 kw. static transformer and rotary converter substation gives an all-day efficiency of 84 per cent. A synchro-

nous motor plant of 400 kw. driving series arc lighters, an all-day efficiency of 74.3 per cent. The alternating current frequency, phase, and voltage changer (motor generator) on three-quarter load 86 per cent. The constant current transformers for alternating arcs at three-quarter load about 88 per cent. Loss in the high-pressure feeders is 2 per cent. Hence efficiency of transmission and transformation is about 80 per cent. (See also 1899, Abstract No. 762.) L. B.

1797. *St. Helens Electricity Works.* (Electrician, 43. pp. 476–482, July 28, 1899.)—The Corporation originally supplied only single-phase alternating current, but have recently added a continuous current station on account of the tramway load. This station is combined with a dust-destructor plant, but has sufficient independent coal-fired boiler-plant. The Electricity Committee purchase steam from the dust-destructor department and pay for it according to the amount of electrical energy generated. The three-wire lighting mains are at 500 volts between the outers, on which all the generators and the battery are placed, the balancing being effected wholly by balancing dynamos direct coupled to a 16 kw. booster. The plant comprises superheaters, a Klein cooling tower and an oil separator placed between the engine and the condenser. No regulating cells are provided on the battery, the booster being used either positively in the charge or negatively in the discharge of the battery. The overhead construction of the tramways was entirely of English manufacture. E. H. C.-H.

1798. *Combined Lighting and Traction Works.* **J. H. Rider.** (Electrician, 43. pp. 297–298, June 23, 1899. Paper read before the Municipal Electrical Association, June 15, 1899.)—Of twenty-two towns where there are electric trams and the Corporation owns electricity works, fourteen have decided on combined works. Accumulators are at their best in a combined station. Not only do they reduce the amount of tramway plant, but they enable the same engines to be used for lighting and traction at the same time; they take the overlapping of the load in the evening and make a nearly constant load possible. The tramway output can easily be much greater than the lighting output, though the latter may have the larger maximum load.

(Discussion, pp. 298–300.) **Wordingham** strongly favoured the combined station as proposed for Manchester. The same generators will supply current simultaneously for both purposes. **Barnard** could not find any saving in combined stations which would counterbalance the objection of using the high-tension system for the tramways. **Chamen** had found accumulators a snare at Glasgow on account of frequent fogs starting at eight o'clock and lasting for hours. Steam plant to

deal with such a case would be cheaper than the very large accumulators required. **Wilmshurst** thought the chief difficulties in the way of combined stations were with the committees. **Giles** stated that at Blackburn a 120 kw. generator was supplying eight cars on a hilly line, and they were steaming no more boilers in the day-time than they did before the tramway load was added. **Quin** had no faith in accumulators. When the time of discharge at a high rate was lengthy, the cost of batteries was more than the cost of the equivalent generating plant, and the arrangement was much less efficient. **Snell** did not agree with the last speaker in saying that the cost of batteries was practically equal to the cost of engines and boilers, but considered the cost per kw. was practically the same as for the steam-dynamos without the boilers. The efficiency of batteries or lighting load under working condition did not exceed 65 per cent. **Rider**, in reply, had found that batteries for a five-hour discharge, which is long enough to take any ordinary peak, cost the same as engines, dynamos, and boilers together, and the chief advantage of the cells was that they gave a twenty-four-hour load.

E. H. C.-H.

1799. *Blackpool Trolley Line.* (Electrician, 43. pp. 474–476, July 28, 1899.)—The generators are two Parsons steam turbo-dynamos of 200 kw. size. The author considers the trolley pole construction here to be particularly unobtrusive. Short brackets on the poles and long arms on the cars have been adopted. The 20-feet trolley arms are constructed to turn a complete circle, and difficulty has arisen in the insulated copper sleeve which this motion necessitates. The arms are constructed of high-grade spring-tempered steel, and are tested with 2,000 lb. at their extremities. E. H. C.-H.

1800. *Electrical Engineering in Switzerland.* (Electrician, vol. 43, 1899.)—Articles descriptive of the Rheinfelden power station (pp. 448–449 and 521–529). The works of Messrs. Brown, Boveri, and Co. (pp. 558–561). The Oerlikon works and the Schaffhausen electricity works (pp. 591–595). Electric Lighting and Traction at Zurich (pp. 623–627). Escher, Wyss and Co.'s works, the Polytechnic, the telephone system and reference to a description of the Sihl electricity works. The Bathausen works at Lucerne, the tramway generating station and the Stansstad-Engelberg, Stansstad-Stans, Stanserhorn and Burgenstock railways (pp. 670–673). The Burgdorf-Thun railway and its generating works (pp. 691–694 and 737–738). The Thun electricity works, the Thun industrial exhibition, and the Interlaken and Jungfrau railway (pp. 738–739).

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1801. *Ashton Electricity Works and Tramways.* (Elect. Rev. 45. pp. 60–65, July 14, 1899.)—An illustrated description is given of the combined lighting, traction, and destructor works of the Corporation of Ashton-under-Lyne. A. H. A.

1802. *Hull Corporation Tramways.* (Electrician, 43. pp. 482–489, July 28, 1899.)—The rails are 94 lb. girder rails with centre groove, rolled in France in 60-feet lengths. The centre groove is adopted to avoid uneven wear of the rails and to give continuous support to the car wheels at the rail joints (which are splayed). The generating station contains an electrically driven three-throw Gwynne pump delivering 1,700 gallons per hour against 150 lb. per square inch, and driven by a 9 H.P. motor which runs normally at 700 r.p.m. on the 500 volt circuit; its speed can be varied from 500 to 800 r.p.m. by shunt and main resistances, while it can further be put on the 220 volt circuit, and regulated between 250 and 400 r.p.m. All the cars have roller bearings. E. H. C.-H.

1803. *Milwaukee and East Wisconsin Electric Railways.* (Street Rly. Journ. 15. pp. 339–352, June, 1899.)—This system of lines comprises 225 miles of track and is therefore among the half-dozen great properties in the States. Realising the importance of a first-class road-bed for high speeds, (45 m.p.h.), the management have lately spent large sums in securing private rights-of-way to cut off curves, in grading the track, &c. The standard city rail is a 6 in. 72 lb. Shanghai section, rolled in 60-feet lengths; it is laid on oak ties at 2-feet centres on a concrete or broken-stone foundation. Two years ago the Falk Company cast-welded some condemned track and thereby have given it an extra five years' life. By the end of this year all the joints within city limits, over 40,000 in number, will be cast-welded. The later work has been done by a local company whose process differs from that of the Falk Company in placing a casing or jacket under and at the sides of the joint. This jacket, into which the metal is poured, is formed by two L-shaped pieces of rolled steel, and adds strength to the cast-iron. Slip joints are provided every 500 feet, and the variation in length with changes in temperature is found to amount to about $1\frac{1}{4}$ in. per 100 feet of track. Hand-car inspection of all high-speed lines is made daily.

During the last two years the overhead construction has been renewed. No. 000 8-trolley wire is the standard and gives absolute satisfaction. The usual difficulties found in other places with this section of wire—in supporting it satisfactorily, running good curves and getting sufficient section—are not regarded as important by the Milwaukee officials. A special clip is used and found very satisfactory. Large section of trolley wire is found the cheapest form of feeder, being uninsulated.

Lighting business is carried on in conjunction with the tramway work, from seven power stations, two of which are merely reserves. A new station, with three-phase transmission, is being built to replace several of these. At present, the cost of production slightly exceeds 1 cent. per kw. hour, of which $0·0066 is for fuel. It is hoped that this figure will be halved in the new station, which will contain two 1,400 H.P. and two 1,100 H.P. Allis-General Electric steam units, besides twenty 100-light Brush arc lighters. The stack is of steel, brick lined, 16 feet diameter in the clear, and 200 feet high: its capacity is 25,000 H.P.

On the long suburban cars, measuring 29 feet over corner posts and 41 feet over all, electric arc head-lights are used, on the ground that power is the cheapest thing found in electric railroading, whilst accidents are the dearest. The arcs search the track a quarter of a mile ahead. The standard car-equipment is with four G.E.-1,000 motors. Tests have shown that the power consumption is less than where two motors of greater aggregate power are used, while repairs are less in spite of the duplication of apparatus. This surprising result is borne out by the 1898 figures which show the low figure of $0·0038 per car mile for repairs of electrical equipment. Several emergency and patrol waggons are kept at different points with the harness suspended over the horses, as with fire-engines. In 1898 the entire cost for maintaining rolling stock up to first-class condition was $0·0091 per car mile, of which $0·0022 was for car bodies, $0·0017 for trucks, $0·0038 for electrical equipments, and $0·0014 for superintendence and sundries.

The twenty-mile run from Milwaukee to Waukesha is regularly made in fifty-five minutes; two Waukesha cars make 380 miles each per day. By rigid punctuality a superior service is given with a longer headway. A surgeon is regularly employed by the company to attend to accidents, and a reserve, amounting to 3 per cent. on the gross earnings, is annually set aside to meet accident claims. The company has 1,673 hands on its pay rolls. The general financial statement for 1898 is given, together with the operating expenses in detail. In the last three years the receipts per car mile have increased by 33 per cent. Unlike most American street railways, sums are annually reserved for depreciation. E. H. C.-H.

1804. *Power Station of the North-Western Elevated Railway, Chicago.* (Street Rly. Journ. 15. pp. 452–454, July, 1899.)—The ultimate capacity of this station is 14,000 H.P., of which half is now installed. The building has a concrete roof and checkered steel-plates, over a basement containing the steam-, exhaust-, and feed-piping, separators, cables, boiler flues, ash conveyors, feed pumps, &c. Three 2000-H.P. Allis-Corliss, cross-compound engines, with cylinders 30 in. and 60 in. by 60 in. stroke, are coupled to Siemens and Halske generators with internal armatures.

Fly-wheels, 25 feet diameter, speed 75 r.p.m. The twenty-four Babcock boilers are fitted with Murphy stokers and coal and ash conveyors. The main steam header is made of 28 in. lap-welded wrought-iron pipe with flanges welded on; it is in three sections, connected to one another by four 8 in. U-shaped steel pipes. Steam pressure, 160 lb. per square inch. All the engines (14,000 H.P.) exhaust into one central condenser of the Weiss counter-current type. The circulating pump only handles the cold injection water, the hot water passing out automatically through a barometric column, or water-leg. It is claimed that this condenser is very economical of power and of water. E. H. C.-H.

1805. *Kingston (Jamaica) Electric Tramways.* **H. E. Raymond.** (Amer. Electn. 11. pp. 317–321, July, 1899.)—The rails (90 lb. in the city, 60 lb. in the country) are laid on steel channel-bar ties, bedded in 8 in. of concrete, which at the rail is raised so as to enclose it half-way up the web. There are six miles of double track, thirty miles of single track. Power is obtained from a reservoir formed by damming up a river 90 feet wide, a mile from the station. Thence an 8-feet pipe of $\frac{1}{4}$-in. steel, riveted in 6-feet sections, is taken to the power house. In cubic contents, this is one of the largest pipe lines in the world. The generators are three-phase, twelve-pole, with stationary field, giving 300 kw. at 550 volts. Each generator feeds three step-up air-blast transformers, which raise the pressure to 14,000 volts for transmission on a steel pole line to Kingston, where it is stepped-down to 345 volts for the rotaries. The relative field excitations are adjusted so that at about $\frac{3}{4}$-load the rotaries will operate non-inductively. The rotaries may be started from rest, from either the alternating or the direct current side. The usual custom is, however, to start the generator and rotary from no cycles, and with a full field on the generator. It was found that with weak fields on the generator and rapid acceleration of speed the rotary will pulsate in and out of step, frequently reversing the polarity of the direct current voltage. This is avoided by bringing the generator up to speed slowly, and keeping a strong field on the same. The normal non-inductive, full load alternating current for the rotary is 340 amperes, but only 200 amperes are necessary to start it from rest and bring it up to speed as an induction motor. E. H. C.-H.

1806. *Three-Phase Transmission for Philadelphia Tramways.* (Street Rly. Journ. 15. pp. 353–356, June, 1899.)—The twenty miles of the Philadelphia and Westchester Traction Company are partly fed from a three-phase substation. The generating station contains G. E. units (550 volts) with a 250 kw. rotary converter working off the 'bus bars and giving 380 volts on the alternating

side. This is stepped up to 6,600 volts and transmitted 10¾ miles to the substation, where, after passing through aluminium fuses, it is again reduced by three 90 kw. oil-insulated transformers to 380 volts and thence to the rotary transformer. Each rotary has a centrifugal governor arranged to throw the circuit-breaker if the speed rises more than 30 per cent. above normal. The shaft is given a to-and-fro motion in its bearings by a coil and make-and-break device at the end of the shaft. E. H. C.-H.

1807. *Lorain and Cleveland Interurban Railway.* (Street Rly. Journ. 15. pp. 265–273, 1899.)—This line is 18½ miles long over private right-of-way, without curves or grades, and the scheduled time for the whole distance is three-quarters of an hour, including many stops. This involves a speed of 50 m.p.h. for much of the route. Each car has four 50 H.P. motors in order to accelerate rapidly. The line is built according to steam-road practice. Double trolley wire is run throughout. The tension of the trolley against the wire is fixed at the high figure of 35 to 40 lb. The trolley wheels are 7 in. in diameter and do not last more than one week. The cars are 34 ft. 6 in. long, and are each provided with a telephone for connection to boxes placed at each quarter of a mile. Each car runs 340 miles per day and requires on the average 140 amperes at 565 volts. An average record is 3·9 units per car mile, and 21·5 lbs. of coal per car mile. Very complete tests of the generating plant are given and show the difference in efficiencies at steady, rated load, and at a small and variable load, as well as the beneficial effect of increased average, though greatly varying, load. E. H. C.-H.

1808. *Düsseldorf-Krefeld Electric Railway.* **G. Braun.** (Elektrotechn. Ztschr. 20. pp. 432–439, June 22, 1899. Report read before the Deutscher Elektrotechniker in Hanover.)—The total length of this line is 22·2 kilometres. The average speed amounts to 40 km. per hour. The motor car is of the double-bogie type, each truck being furnished with a 35–40 H.P. enclosed gearless motor. A train consists of one motor and two trailer cars. The length of the rails is twelve metres, and the weight 27·5 kg. per metre run. Each motor car is provided with two trolleys of the sliding-contact type. Power is supplied from a generating station at Oberkassel and an accumulator substation at Fischeln, the P.D. amounting to 600 volts. There are three feeding-points; the overhead conductor, which consists of two hard-drawn copper wires 9 mm. in diameter, is divided into six sections, and each section is subdivided into 1 kilometre lengths. The feeders are supported by insulators, mounted on wooden cross-arms, fixed to the poles above the points of attachment of the span-wires. The line was opened in December, 1898. A. H.

1809. *Power for Electric Traction.* **J. G. Scott.** (Elect. Rev. 44. pp. 963–964, June 16th; 1070–1072, June 30th; and 45. pp. 78–80, July 14th; 219–220, August 11th; 384–385, September 8, 1899.)—The tardy but more substantial development of electric traction in Great Britain is compared with that of America. There are at present thirty lines with a total of 260 miles of single track at work in Great Britain. The advantages of combined lighting and traction stations running under various systems are discussed. Many modern lighting stations are being designed on the 440 volt three-wire system in order that the dynamos may be interchangeable. Separate 'bus bars are necessary. The Bradford station is taken as an example. With 220-volt dynamos two may be joined in series for traction work. The Oxford system, which is employed in seven British lighting stations, has not yet been adapted to traction. In alternating stations separate generators are installed for the tramways, as at Blackpool, Dover, and Halifax; or, as at Plymouth, both alternating and continuous current generators may be driven off the same engine shaft. In Glasgow, separate lighting and traction stations are being built; while at Manchester, Wordingham recommends that the two be combined.

Typical daily and annual load curves on both the lighting and tramway systems are given, and their influence on the stand-by plant required explained. The advantage of the combination is much more marked in stations with a small than with a large lighting load. The traction switchboard of the Bradford station is figured and described, as well as the automatic cut-outs and the "Ajax" lightning arrester.

Electrolysis of water-pipes, &c., owing to the earth return, is effectually prevented by the Board of Trade regulations, which are quoted *in extenso*. The switchboard panel, required to make the necessary measurements in conforming to these regulations, is figured and explained. An extraordinary case is quoted from an American source, in which the time of a ten-mile run was reduced from sixty to twenty minutes, by improving the feeder system and the earth return.

The dynamos employed in the Bradford station for either lighting or traction are described, with particular reference to the connections for changing them over and for running them in parallel with compound excitation on the traction load. They are 400 kw. Siemens machines, giving an efficiency by the Hopkinson test of 97·7 per cent. at full load. L. B.

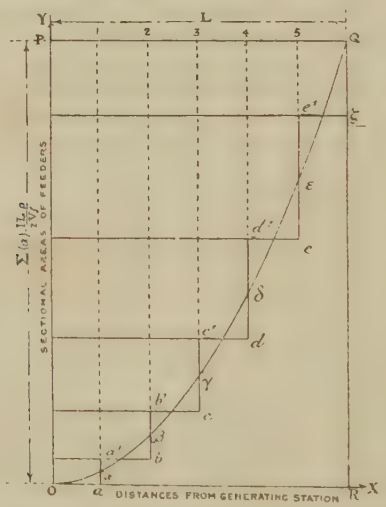
1810. *Electric Traction.* (Cassier, vol. 16. August, 1899.)—Illustrated articles on electric traction by various authors as follows:—**F. S. Pearson**, pp. 257–282, The Latest Developments in Conduit Railways; **R. W. Blackwell**, pp. 283–302, Electric Tramways in Great Britain; **L. W. Serrell**, pp.

303–318, Building an Electric Railway; **J. G. White**, pp. 319–336, Overhead Construction; **C. T. Hutchinson**, pp. 337–356, The Development of the Electric Railway Motor; **T. Reid**, pp. 357–370, Early Traction History; **A. V. Abbott**, pp. 371–380, Electrolysis from Railway Currents; **B. Taylor**, pp. 381–388, The Municipal Ownership of Tramways in the United Kingdom; **J. A. Brill**, pp. 389–424, The Development of the Tram-Car; **M. K. Bowen**, pp. 425–432, Rails and Rail Joints; **L. Bell**, pp. 433–438, Light Electric Railways; **F. J. Sprague**, pp. 439–460, Multiple Unit System for Electric Railways; **G. R. Mair**, pp. 461–486, The Electric Locomotive; **D. C. Jackson**, pp. 487–501, Polyphase Currents for Railways; **C. F. Uebelacker**, pp. 502–506, The Selection of Rolling Stock; **H. Lloyd**, pp. 507–517, Storage Batteries and Electric Railways; **W. J. Clark**, pp. 518–526, American Electric Railways from a Business Standpoint; **P. V. McMahon**, pp. 527–540, The City and South London Railway. EDITOR.

1811. *Return Feeders for Electric Railways.* **B. Böhm-Raffay.** (Zeitschr. Elektrotechn. Wien, 17. pp. 271–274, June 4th; 367–374, July 2nd; 381–385, July 9th; and 407–411, July 23, 1899. Read before the Elektrotechnischen Vereine in Wien, March 1, 1899. Abstracted in detail by A. Mauduit in Écl. Électr. 19. pp. 489–497, July 1, 1899.)—Let there be n cars equidistant from each other along a line, the generating station being at one end of the line, and the furthest car at the other. Let the total resistance of the track return be R, and the total current drawn by the cars I. The fall of potential, V, along the rails will in that case be $\frac{RI(n+1)}{2n}$. With a moderately frequent service, n will be fairly large, so that it is sufficient for practical purposes to take $V=\frac{RI}{2}$ (the value corresponding to $n=\infty$). The fall of potential may be greatly reduced by the use of insulated feeders connected to the rails at certain points. The author considers the following cases:—

1. Track straight: (1) Generating station at beginning of line, and both beginning and end of line, as well as m intermediate equidistant points, connected to station by feeders of such resistance as to maintain the points of connection with the rails at the same potential. The greatest P.D. between any two points in the rails may be shown to be $\frac{RI}{8(m+1)^2}$, or only $\frac{1}{4(m+1)^2}$ of the P.D. when no return feeders are used. If V_f stand for the allowable fall of potential in each feeder, a for the sectional area of any feeder, L for the total length of the line,

and ρ for the resistivity of the copper used, then it may be shown that the total sectional area of copper is $\Sigma(a)=\frac{IL\rho}{2V_f}$, *i.e.*, it is *independent of the number of feeders*. The total volume of copper $\Sigma(v)$ is given by $\Sigma(v)=\frac{IL^2\rho}{3V_f}\left\{1+\frac{1}{2(m+1)^2}\right\}$. This has a maximum value $\frac{IL^2\rho}{2V_f}$ for $m=0$, corresponding to the case of a single feeder running to the far end of the line, and a minimum value $\frac{IL^2\rho}{3V_f}$ for $m=\infty$, corresponding to an infinite number of feeders. It must be noticed, however, that as m increases $\Sigma(v)$ very rapidly approaches its minimum value. The sectional area a_r of the r^{th} intermediate feeder is $\frac{IL\rho}{(m+1)^2V_f}\cdot r$. The following extremely neat construction for graphically determining the sectional areas of the consecutive feeders is given by the author. Draw the rectangle (see fig.) OPQR, in which $OP=\Sigma(a)$, and $OR=L$, and the parabola OQ, whose equation is $x^2=\frac{L^2}{\Sigma(a)}y$. The area of the rectangle represents the maximum volume of copper ($m=0$), and the parabolic area



OQP the minimum volume ($m=\infty$). For any finite number of feeders, the volume will lie between these limits. Let there be five intermediate feeders, connected to equidistant points 1, 2, 3, 4, 5. From 1 draw $1a$ parallel to YO, and intersecting the parabola in a; lay off $a\,a'=a\,a$, then $a\,a'$ gives the sectional area of feeder 1, and the rectangle $O\,a'$ the corresponding volume of copper. Similarly, through 2 draw $2\,b$, intersecting the parabola

in β, and lay off $\beta b' = b\beta$; then $b b'$ gives the area, and the corresponding rectangle the volume, of copper for feeder 2, &c.; ζQ is the area of the feeder connected to the extreme end of the line. The graphical method of solution is extended by the author to the case where the feeding-points are not equidistant, and to the problem of finding the feeding-points when the sectional areas of the feeders are given. It is further shown that for *a fixed number of feeders the least volume of copper corresponds to equidistant feeding-points.* (2) Same conditions as in case (1), but with generating station at middle of line. The formulæ in this case are:—

$$\Sigma(a) = \frac{IL\rho}{8V_f} \text{ and } \Sigma(v) = \frac{IL^2\rho}{12V_f}\left\{1 + \frac{1}{(2m+1)^2}\right\},$$

both sides of the line being taken into account. (3) Conditions as in (1), with m feeders, but end of line not connected to a feeder: the maximum P.D. in line $= \frac{RI}{2(2m+1)^2}$;

$$\Sigma(a) = \frac{IL\rho}{2V_f}\left\{1 - \frac{1}{(2m+1)^2}\right\}; \text{ and } \Sigma(v) = \frac{IL^2\rho}{3V_f}\left\{1 - \frac{1}{(2m+1)^2}\right\}.$$

(4) Conditions same as in (1), but neither beginning nor end of line connected to a feeder: maximum P.D. in line $= \frac{RI}{8m^2}$;

$$\Sigma(a) = \frac{IL\rho}{2V_f}; \text{ and } \Sigma(v) = \frac{IL^2\rho}{3V_f}\left\{1 - \frac{1}{4m^2}\right\}.$$

2. Track circular, and *feeders not following line of track*: (1) Line a semicircle, with generating station at centre of arc, and m feeders along radii of semicircle. $\Sigma(a) = \frac{IL\rho}{\pi V_f}$, and $\Sigma(v) = \frac{IL^2\rho}{\pi^2 V_f}$. (2) Line a complete circle, with generating station at centre, and radial feeders: $\Sigma(a) = \frac{IL\rho}{2\pi V_f}$, and $\Sigma(v) = \frac{IL^2\rho}{4\pi^2 V_f}$. (3) Line a complete circle, with generating station on circumference, and feeders along chords: $\Sigma(a) = \frac{IL\rho}{\pi(m+1)V_f} \cdot \frac{\sin \frac{m}{m+1} \cdot 90^\circ}{\sin \frac{90^\circ}{m+1}}$, and $\Sigma(v) = \frac{IL^2\rho}{2\pi^2 V_f}$.

A. H.

1812. *Track Construction in Cincinnati.* (Street Rly. Journ. 15. pp. 433–435, July, 1899.)—The large mileage of the Cincinnati Street Railway Co. was laid five years ago with 95-lb. grooved

girder rail spiked to oak ties, bedded in concrete. The officials state that this has given reasonable satisfaction, except that the joints have had to be raised two or three times. Where the soil is porous, the concrete foundations have gone down and the management prefer broken stone foundations in such places. From observation on a reconstructed line, it appears that a grooved rail takes 30 per cent. more power than a step rail. Contrary to expectation, a length of track which was laid with a split rail and broken joints supported on cast-iron chairs laid on concrete pedestals has lasted the five years quite as well as the construction described above. Cast welded joints are standing well, except where a light 6-inch rail was used. The management are thoroughly satisfied with double trolley equipment which has been used throughout. It avoids all danger of electrolysis and is not considered more unsightly than single wire. E. H. C.-H.

1813. *Electric Welding of Rails.* **H. F. A. Kleinschmidt.** (Street Rly. Journ. 15. pp. 362–363, June, 1899.)—In the early days, electric welding produced a change in the nature of the steel, but the writer found a simple process for avoiding this by making the weld from a boss on a bar instead of from a flat bar. As soon as the welding heat is reached, current is cut off and simultaneously heavy pressure is applied while the weld is artificially cooled. The comparatively cold portions of the bar around the weld prevent the more plastic metal from spreading, while the pressure prevents coarse crystallisation. In fact the effect is like hammering the steel.

In the summer of 1898, ten miles of track were welded in Brooklyn in the hottest weather and only 0·5 per cent. of the joints have broken: all the breaks were in old 12-hole rails, and none in 8-hole rails. A 75 kw. booster is used on the trolley circuit and makes a good weld even with only 300 volts. The rails are first cleaned with a sand blast. Fifty miles of track in Buffalo are now being welded electrically. E. H. C.-H.

1814. *Repair Shops at Cincinnati.* (Street Rly. Journ. 15. pp. 360–362, June, 1899.)—The Street Railway Co. of this town has put down very complete repair shops with all possible labour-saving devices. It winds all its own armatures and fields, and makes its own commutators from scrap trolley wire. Each motor has two sets of numbered brushes which are kept in sperm oil when not in use. Each set is put in use every other day in summer and every three days in winter. This practice makes two sets of brushes last a year, and also adds 100 per cent. to the life of the commutator. Trolley wheels are manufactured from a mixture of eight parts of copper and one part of tin by a turret lathe worked by a man, receiving a dollar a day, who finishes 125 wheels a day. E. H. C.-H.

1815. *Riker Motor Cars.* (Electrician, 43. pp. 260–262, June 16, 1899.)—A single motor and differential gearing are used. The ¾ kw. size runs at 1,200 r.p.m. and weighs 80 lb., while the 3 kw. size at 800 r.p.m. weighs 285 lb. Standard types of accumulator are used. An ingenious device attached to the car controller cuts out the battery when fully charged, thus avoiding necessity for skilled labour for this operation. The controller, which operates by series-parallel arrangement of the cells, gives three speeds forward, two backwards, and an emergency brake by use of the motor. E. H. C.-H.

1816. *Motor Cars.* **É. Hospitalier.** (Ind. Élect. 8. pp. 287–305, July 10, 1899.)—Descriptions of various electric motor cars of the French automobile club. EDITOR.

1817. *American Motor Cars.* **T. B. Booth** and **S. S. Sherman.** (Elect. World and Engineer, 33. pp. 575–579, 878–881; 34. pp. 127–129, 173–174, 1899.)—Descriptions in detail of several types of American automobiles. EDITOR.

1818. *Electric Power from Windmills.* **C. L. Crandall.** (Railroad Gazette, 31. p. 318, 1899. Paper presented at the Boston meeting of the American Association for the Advancement of Science.)—The author gives estimates of the lamp-hours per day produced by a ¾ kw. dynamo and a 12-foot aermotor. The paper is illustrated with diagrams showing the relation, found by experiment, between the B.H.P. of the mill and the wind velocity, when the speed is adjusted for maximum efficiency, and various other data. The wind velocities were averaged from the records of the anemometers of the State Weather Bureau at Ithaca, and it was found that the 12-feet motor would provide a minimum of 19 lamp-hours (16 c.p.) per day, while a 16-feet aermotor would give 35 lamp-hours, under the conditions assumed. A. H. A.

1819. *Charging for Alternating Current Supply.* **G. Benischke.** (Elektrotechn. Ztschr. 20. pp. 454–456, June 29, 1899. Report read before the Deutscher Elektrotechniker.)—Consumers using apparatus having a low power-factor (such as induction motors or simple arc lamps in series with choking-coils) increase the cost of production of electrical energy in two ways: (1) by necessitating the use of a larger generating plant, (2) by reducing the efficiency of working. It seems, therefore, only fair that such consumers should be made to pay a somewhat higher price per

unit than those using non-inductive loads. The plan suggested by the author consists in making the shunt circuits of the integrating wattmeters supplied to consumers using inductive loads slightly inductive, so as to cause them to register somewhat high. A. H.

1820. *High Efficiency Incandescent Lamps.* **B. L. Montel.** (Zeitschr. Elektrotechn. Wien, 17. pp. 380–381, July 9, 1899.)—From the curves of consumption and candle power, and assuming various prices per lamp and per unit of electrical energy, curves are drawn of the price per c.p. hour at various stages in the life of a lamp. To obtain the maximum economy the lamp should be replaced when this curve has reached a minimum value, usually for high efficiency lamps after 250 to 300 hours only of its life, although it would last much longer before burning out. The cost of the new lamps necessary reduces the apparent economy of high efficiency lamps to from 30 to 60 per cent. of what it would be if the life were as long as that of low efficiency lamps. Details of costs are given. The drop of candle power of high efficiency lamps is also much greater than with those of lower efficiency.
L. B.

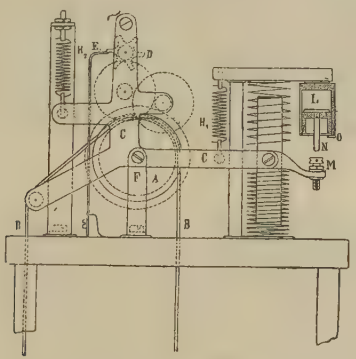
1821. *Desaymar High Efficiency Incandescent Lamp.* (Écl. Électr. 19. pp. 497–499, July 1, 1899.)—This paper gives the following figures for watts per candle-power of the "Desaymar" lamp recently put on the market in Paris by De Marçay & Co.:

2·5 to 2·7	watts	for	lamps of	10 C.P.
2·3 „ 2·5	„	„	16	„
2 „ 2·3	„	„	20	„
1·8 „ 2	„	„	32	„

The life of the lamps is guaranteed for at least 600 hours. The watts per candle necessarily increase with the life of the lamp, but not very largely; thus a 20 c.p. lamp after burning 1,100 hours only takes 2·8 watts per c.p. In these lamps a rather long filament is employed which is wound in a spiral form, and a cylinder of enamel covered with a thin coating of glass is placed along the axis of the spiral. The makers attribute to this cylinder a certain importance in increasing the power of the light for a given expenditure of electrical energy, as it will give a better distribution of the light by reason of the multiple reflections.
E. C. R.

1822. *Large Incandescent Lamp.* (Amer. Electn. 11. p 340, July, 1899.)—This article describes what is stated to be the largest glow-lamp ever made. It is 5,000 candle power, and constructed for use in a lighthouse, as its fog-penetrating properties are much superior to those of an arc-lamp. The lamp is of the two filament type, the two filaments being in parallel and taking 236 volts, the power taken is about 3 watts per c.p., the total power being therefore about 15 kilowatts. It is made by the Bryan-Marsh Company. E. C. R.

1823. *Arc Lamp.* (Elekt. Runds. 16. p. 187, 1899.)—This is a description of a focussing arc-lamp mechanism made by Messrs. Siemens and Halske. Steady burning is attained by great freedom of motion and sensibility in the regulating mechanism. Friction is overcome by introducing two spiral springs H_1 and H_2



acting upward on either side of the pivot F, thus balancing each other and supporting the weight of the moving parts. Also by leaving the dash-pot spindle N normally disconnected from the moving lever C, and only coming into play to prevent extreme variations of the arc. L. B.

TELEGRAPHY AND TELEPHONY.

1824. *Telautograph with Rotary-field Drive.* **F. J. Patten.** (Elect. World and Engineer, 34. pp. 233–234, August 12, 1899.) —Devices of the pantagraph type, for transmitting and receiving line drawings, have the general defect that the mechanism works step by step, and thus produces a more or less serrated line in place of a smooth original. To obviate this, the author adopts a motor system of the rotary-field type, driven by direct current applied to a gramme ring in such a way as to produce a rotating magnetic field which operates upon a closed-coil armature in synchronous rotation with the field. In place of commutator-bars, a circular mercury commutator is used; it consists of an ebonite disc having four concentric troughs containing mercury. A revolving radial knife-edge connects the mercury commutator at different points through separate wires to the respective parts of the motor field-ring; the rotary-field motor consequently reproduces the motion of the radial arm of the commutator. The sending pantagraph translates the two components of the motion of its stylus into rotary movement of two corresponding commutators. The motion is reproduced by two corresponding motors. R. A.

1825. *Photographic Receiver for Cable Signals.* **J. Pinter.** (Zeitschr. Elektrotechn. Wien, 17. pp. 415–418, July 30, 1899.) —The sending apparatus appears to be similar to the Delany brush-contact instrument, but hand-sending, or any of the auto-transmitters, could equally well be used. The receiver is a telephone, with a mirror attached vertically, in a very delicate and effective manner, to the diaphragm. Light from a bright point is reflected from the mirror, giving an image on a rotating cylinder which progresses axially along a screw; the cylindrical surface is covered with photographic paper, upon which, when the mirror is at rest, a spiral line is formed. In order mechanically to magnify the motions of the diaphragm, and to convert them into angular deflections, the mirror is hinged at the top and actuated by a rod lightly touching it at the middle; this rod projects from the middle of the diaphragm to which it is rigidly attached. The "hinge" suspension is simply a magnetic contact between the top of a thin iron plate fixed to the back of the mirror, and a two-point pole of a magnet, the two points being close together in a horizontal line. The second pole of the suspension magnet magnetises a light, straight, vertical spring, the pointed top of which extends to the middle of the back of the mirror; this spring is attached just below its top to the end of the rod which projects from the telephone diaphragm. It is necessary to eliminate the effect of thrusts due to the natural period of the

telephone diaphragm; the author, therefore, rates the auto-sender so that the electric impulses are of the same period as the fundamental of the diaphragm; he claims that, with a condenser between the terminals of the telephone, he can then effectively damp the natural "after-swings" of the diaphragm. A photograph of "slip" obtained by the apparatus is a proof of the capabilities of this type of instrument. There seems to be absolutely no limit to the "speed" to be attained by photographic recorders; the author mentions 600 words as being recorded in twenty-two seconds (German words). R. A.

1826. *Benches for Telegraph Apparatus.* **E. Lönnqvist.** (Journ. Télégraph, 23. pp. 58–60, 1899.) — In this article the author concludes his description of the arrangements of telegraphic apparatus adopted by the Director-General of Swedish Telegraphs (see 1899, Abstract No. 1107). Details and drawings are given of the benches that are found most convenient for instruments. The legs of the benches are slotted so that the wires can be brought up inside them. For the purpose of further secreting the connections, the top of the bench is made hollow. The switches are hidden to protect them from dust and mechanical injury. R. A.

1827. *Translator for the Printing Telegraph.* (Journ. Télégraph, 23. pp. 49–52, 1899.)—The relay at Brégenz, making it possible to use Baudot's telegraph between Paris and Vienna, is an improvement on the translator at Turin which works the Paris-Rome installation. It is described in detail. M. O'G.

1828. *Morse Sounders.* (Archiv. Post Tele. 9. pp. 427–433 1899, and Elektrotechn. Ztschr. 20. pp. 370–371, 1899.)—An account is given of the Morse sounder as used by the British Post Office, and it is recommended for adoption in Prussia and Germany. The two articles are practically identical. R. A.

1829. *Electrical Radiation.* **A. V. Abbott.** (Elect. World and Engineer, 33. pp. 616–617, 652–653, 701–702, 749–750, June 3rd, 802–803, June 10, 1899.)—This is a compilation including an account of the ordinary apparatus used in wireless telegraphy, and some idea of electrical radiation. R. A.

1830. *Wireless Telegraphy.* **I. Kitsee.** (Elect. World and Engineer, 33. pp. 871–873, June 24, 1899.)—A telephone receiver substituted for a coherer was found to respond to electric waves, even when the diaphragm was of rubber and the coil removed. The law deduced is that the air in proximity to the conductors conveying high-frequency waves acquires a pulsatory motion, which it may transmit to a diaphragm. The rigid chamber behind the diaphragm should be connected to two terminals in contact with media at different potentials, which media may be the air or the earth. M. O'G.

1831. *Simultaneous Telegraphy and Telephony.* **C. Selden.** (Elect. Rev. N.Y. 34. p. 332, 1899. Paper read before the Railway Telegraph Superintendents' Association, Wilmington, May 17, 1899.)—Van Rysselberghe reduces the abruptness of the Morse signal by an inductive resistance called a graduator, and bridges the Morse keys, when open, by a capacity so that a receiver is not affected by the make and break. Two telegraph wires are used in preference to an earth return, and the telephone instruments at each end are connected to them through condensers. Commercial conversation was held over 200 miles of iron wire. It is regrettable that no call exists for the telephones on the "simultaneous" system other than the use of the Morse telegraph. M. O'G.

1832. *Single Exchange Line for Five Subscribers.* **J. H. West.** (Journ. Télégraph, 23. pp. 52–57, 1899.)—By means of a special commutator relay for each group of five subscribers the exchange can call up any of the five without disturbing the others and without any other being able to ring in or listen in. A continuous signal is given to the four others that the line is busy. Since the average number of connections is twelve a day, the five subscribers' calls will rarely coincide and the rent can be reduced to two-fifths of its present figure with profit. The action and instruments at the exchange are unaltered, except that to call No. 5, five impulsive currents must be sent into the relay; to call No. 4, four impulses, and so on. M. O'G.

1833. *Germain's Loud-Speaking Transmitter.* **G. Dumont.** (Électricien, 17. pp. 305-308, 1899.) — Carbon granules are replaced by another semi-conducting substance so that 20 volts may be safely applied. The container is a cylindrical box whose two ends are connected by a flexible membrane. M. O'G.

SCIENCE ABSTRACTS.

PHYSICS AND ELECTRICAL ENGINEERING.

DECEMBER 1899.

GENERAL PHYSICS.

1834. *Surface Tension of Aqueous Solutions.* **C. Forch.** (Wied. Annalen, 68. 4. pp. 801–816, August, 1899.)—Slight traces of a fatty acid in water produce only a slight diminution of the surface tension at first. If the relation is plotted graphically, ordinates representing surface tensions and abscissæ being $\sqrt[3]{m}$, the curve in its initial portion is parallel to the axis of abscissæ. This changing-point of the curvature approaches lower values of m as the amount of carbon in the acid increases. E. E. F.

1835. *Automatic Mercury Pump.* **R. R. Lawrence.** (Science, 9. pp. 510–511, 1899.)—The novelty about this pump is its electrical control, which is so arranged that sparks made by contact do not foul the mercury. E. E. F.

1836. *Efflux of Gases.* **R. Emden.** (Wied. Annalen, 69. 1. pp. 264–289, September, 1899.)—The author describes the phenomena of periodic condensation observed in the efflux of gases from narrow openings, and photographs them by Dvorak's method of striæ. He shows that stationary sound waves are produced in all gases as soon as the pressure exceeds 1·9 atmospheres. E. E. F.

1837. *Transformation of Iron and Steel.* **H. Le Chatelier.** (Comptes Rendus, 129. pp. 279–282, July 31, 1899.)—The author studies the recalescence and magnetic transformation of iron and steel by means of experiments involving very slow changes of temperature. In steel there is no simple contraction

on cooling; but at the transformation-point there is an expansion of one constituent and a contraction of the other, which, in steel containing 0·9 per cent. of carbon, exactly neutralise each other. In iron the changes of volume are still more complicated. Transformation is gradual, there being no fixed point of transformation as in other simple bodies. The author compares the behaviour of iron with that of selenium, which is stable only between 60° and 214°. Outside these limits only the amorphous variety, vitreous or liquid, is stable. E. E. F.

1838. *Equations of Condition.* **O. Wiedeburg.** (Wied. Annalen, 69. 1. pp. 66–82, September, 1899.)—The author arrives at Gouy's views along an independent line of argument. Gouy considers a system in stable equilibrium, upon which a certain external influence is exerted, consisting of a change of shape or volume, an addition of heat or electric charge, or generally, as the author would express it, in a change of a certain quantity value M of the system. The effects of this influence are of two kinds: either unenduring like changes of temperature, pressure, electric potential, *i.e.*, of a foreign intensity value J′; or enduring, like changes of shape, volume, chemical composition, *i.e.*, of a foreign quantity value M′. Gouy concludes that "unenduring effects are directed against the external influence, while enduring effects favour it." The author puts this in a slightly different form: If the effects $\partial J'$ and $\partial M'$ are regarded as the causes of "reactions" of the system upon the primarily modified value M, it may be said that the reaction ∂M has a sign opposite to that of the original influence $\partial M'$ if due to unenduring effects $\partial J'$, but the same sign if due to enduring effects $\partial M'$.
E. E. F.

1839. *Recent Research on Chromosphere.* **H. Deslandres.** (Paris Soc. Franc. Phys. Bull. 130. pp. 2–4, 1899.)—A paper similar to that referred to in Abstract No. 899 (1898). C. P. B.

1840. *Gallium in the Sun.* **W. N. Hartley** and **H. Ramage.** (Astro. Phys. Journ. 9. pp. 214–220, 1899.)—The authors, in the course of their examination of minerals, meteorites, &c., have found the element gallium so common a constituent, though always in very small quantity, that they deemed it advisable to determine if there were any traces of it in the sun. Attention was confined to the two best known lines of gallium at λλ 4172 and 4033. Photographs of the spectra of specially prepared pure iron, various gallium compounds, and the solar spectrum were obtained with the large (21 feet) Rowland concave

grating spectroscope of the Royal University of Ireland, and the plates carefully measured. After considering the possible coincidences with adjacent lines due to other elements, the authors conclude that gallium is present in the sun. C. P. B.

1841. *Heat Radiation of the Stars.* **G. E. Hale.** (Astro. Phys. Journ. 9. pp. 360–362, 1899.)—The author commences by reviewing the negative results of C. V. Boys, who used in connection with a 16-inch reflecting telescope a radio-micrometer sensitive enough to show the heat equivalent to that of a candle 1·71 miles away. E. F. Nichols, of Dartmouth College, has spent much time in perfecting the radiometer, and the present form of the instrument is for certain purposes considered superior to either the radio-micrometer, bolometer, or thermopile. In July, 1898, Nichols was invited to test his instrument at the Yerkes Observatory, and the apparatus was installed in the heliostat room, where the stability was so perfect that deflections to tenths of a millimetre could be observed. The radiometer used consisted of a suspension system formed of two mica discs, each 2 mm. in diameter, blackened on one face, and supported by a light cross arm on either side of a thin glass staff, hung by an exceedingly fine quartz fibre in a partial vacuum. Both vanes were exposed to the radiation of the sky at the focus of a silvered glass mirror of 24 inches aperture, fed with light by a siderostat outside. The rays entered the radiometer through a small window made of *fluorite*. With the apparatus so arranged a deflection of 0·1 mm. would be given by a candle fifteen miles distant, neglecting loss by reflection and atmospheric absorption. Seven determinations of the heat radiation of Arcturus gave a mean deflection of 0·60 mm. Vega gave a mean deflection of 0·27 mm. Although the quantitative value of these results is not insisted upon, the author considers that they show the reality of the detection of stellar heat radiation. C. P. B.

1842. *Variations of Apparent Horizon.* **F. A. Forel.** (Comptes Rendus, 129. pp. 272–274, July 31, 1899.)—The author has recently been engaged in the study of aerial refractions and mirages on the surface of Lake Léman, and in the course of his work has been able to make some observations on the displacement of the apparent horizon. The work was carried out at Morges, in a laboratory on the border of the lake, where he could command a length of horizon of about 16 kilometres. Observations were made with a telescope mounted on a stone pier of such height that the horizon was 5 or 6 kilometres distant, and the level was determined by sights, both direct and with an artificial horizon. The angular differences between the *true* and

apparent horizon varied from $+501''$ and $-272''$, showing a total variation of $773''$, or over $13'$ of arc.

The factors causing this difference are: temperatures of the air and water, humidity and agitation of the air, direction and quality of wind, and variations of atmospheric pressure.

Tables are given of the various values observed, from a discussion of which the following general rules are deduced:—

1. The possible error in the position of the true horizon as deduced from observations of the apparent horizon is greater when the air is calm than when it is agitated.

2. It is greater when the air is warmer than the water.

3. Since the observations are more uncertain when the air is calm and warmer than the water, morning observations are better than those made in the afternoon. C. P. B.

1843. *Temperature Variations in the High Atmosphere.* **L. T. de Bort.** (Comptes Rendus, 129. pp. 417–420, August 21, 1899.)—Since April, 1898, more than a hundred unmanned balloons (*ballons-sondes*) have been sent up from Trappes, of which seven exceeded the altitude of 14,000 m., twenty-four of 13,000 m., and fifty-three of 9,000 m. Kites have also been used. In recent months both the old thermometers and the new improved thermometers have been employed, in order to secure comparable results. Thus continuous temperature observations, extending over more than a year, have been obtained for the first time. They show greater variations in the temperature of the higher strata than had been expected. The isothermal of 0° may not be met with below 4,000 m.; the isothermal of $-25°$ has been found at an altitude of 3,000 m. in winter, and at 7,000 and even 8,000 m. in September. The isothermal of $-40°$ is generally near 9,000 m., but it has gone up higher at the end of the summer, and descended to 6,000 m. during winter. A temperature of $-50°$ has never been observed below 8,000 m.; in September, 1898, and July, 1899, it did not occur below 12,000 m. The higher strata of the atmosphere seem to be warmest towards the end of the summer, and coldest towards the end of the winter. But the temperature may change greatly in the course of a few days. Thus the isothermal of $-40°$ was at an altitude of 8,500 m. on March 14th last, and at 6,600 on March 24th. H. B.

LIGHT.

1844. *Astronomical Telescope Objectives.* **H. Harting.** (Zeitschr. Instrumentenk. 19. pp. 104–110, 1899.)—A discussion of methods of calculation based upon first assuming the axial thicknesses of the lenses to be negligible, and then applying the requisite corrections. A numerical example of the calculation is given. A. D.

1845. *Paris Exhibition Siderostat.* **P. Gautier.** (Paris, Soc. Phys. Séances, 1899, 1. pp. 29–50.)—A paper similar to that referred to in Abstracts Nos. 1131 and 1657 (1899). EDITOR.

1846. *Corrections for Chromatic and Spherical Aberration in Astronomical Telescopes.* **R. Steinheil.** (Zeitschr. Instrumentenk. 19. pp. 177–183, June, 1899.)—A comparison of three objectives, comprising that of the Königsberg heliometer, another similar lens, also by Fraunhöfer, and a new lens of Jena glass. The errors introduced by the secondary spectrum tend greatly to exceed those due to spherical aberration. A. D.

1847. *Reversing Prism.* **B. Wanach.** (Zeitschr. Instrumentenk. 19. pp. 161–177, 1899.)—The reversing prism with two refractions and one reflection, used for reversing images without deviating the axis of the rays, is fully discussed, with reference to its applications. A. D.

1848. *Optical Properties of Minerals.* **H. Rosenthal.** (Wied. Annalen, 68. 4. pp. 783–800, August, 1899.)—The author studied the absorption, emission, and reflection of quartz and mica, and compared them with the properties of glass in the region extending from 5,000 to 10,000 $\mu\mu$. In this region the bodies mentioned have characteristic properties which make them specially valuable for testing Kirchhoff's law of radiation. The relation between emission, absorption, and reflection formulated by that law is strictly verified. E. E. F.

1849. *Dispersion of Selenite.* **W. König.** (Wied. Annalen, 69. 1. pp. 1–11, September, 1899.)—The author solves the problem of determining the mean wave-length of a group of rays

by photographing an interference phenomenon whose dependence upon wave-length is known, and determining the wave-length from the distance between the interference fringes. To obtain conditions as uniform as possible the interference fringes of a selenite wedge between crossed and between parallel Nicolls are photographed. The author finds the mean wave-length of curve of sensibility of ordinary Schleussner plates to be 428 $\mu\mu$.
E. E. F.

1850. *Bravais Points.* **P. Lefebvre.** (Comptes Rendus, 128. pp. 930–933, 1899.)—In a centric optical system of foci FF′ and optical constant H a real isosocles triangle can be formed with FF′ as its base and $\sqrt{H}$ for its sides. The summit of this triangle is called by the author the "pole" of the system. If O is this pole, and B and B′ are the Bravais points, OB may be made to coincide with OB′ or its prolongation by making it rotate round the pole O by a certain angle called by the author the "characteristic angle." To construct the image of an object it suffices to turn the radius vector joining the pole to the foot of the object on the axis round the pole through the characteristic ngle. The foot of the image then lies on the axis at the end of he radius vector or its prolongation. The image is upright in the first case, and reversed in the second. Its ratio to the object is equal to that of the distances of the pole from the foot of the image and the object respectively, multiplied by the refractive index of the first medium with respect to the second. A centric optical system is completely determined when the axis, a pole, the characteristic angle, and the refractive indices of the extreme media are given. From these data the foci, principal planes, and nodal points can be immediately deduced. E. E. F.

1851. *Kirchhoff's Law.* **A. Cotton.** (Astro. Phys. Journ. 9. pp. 237–268, 1899; also Revue Générale des Sciences, February 15, 1899.)—This is a somewhat lengthy discussion of the position at present held by Kirchhoff's law in the explanation of the various phenomena of emission and absorption of radiant heat and light. C. P. B.

1852. *Blue Steam Jet.* **A. Bock.** (Wied. Annalen, 68. 4. pp. 674–687, August, 1899.)—The blue steam jet described by Helmholtz has a colour of a composition strictly identical with that of the blue of the sky, the intensities of the components being, in accordance with Rayleigh's law, inversely as the fourth power of their wave-lengths. Under conditions of illumination similar to those obtaining in the atmosphere the blue steam jet shows a whitish colour which, when observed at right angles to

the ray, can be made to disappear by turning the analyser. Examination with intense concentrated light shows that the red, yellow, and green rays are polarised, whereas the blue and the violet rays are unpolarised, the result being a phenomenon analogous to Tyndall's "residue blue." The transmitted ray shows reddish-yellow colouration. Regular diffraction does not occur in the blue jet. The jet is invisible when illuminated by red light, but appears distinctly in a blue light, and therefore behaves like a blue body. It is probable that the diameter of the droplets is equal to the wave-length of the blue rays. E. E. F.

1853. *Pressure in Radiometers.* **E. Riecke.** (Wied. Annalen, 69. 1. pp. 119–124, September, 1899.)—The discrepancy between the author's values and those found by Donle is due to an error in the reduction to c.g.s. units and to an imperfect estimation of the moment of inertia of the paddle-wheel. When these errors are corrected values are obtained for the pressure on the radiometer vanes which closely agree with those of Donle. E. E. F.

1854. *Dispersion Model.* **J. H. Vincent.** (Phil. Mag. 46. pp. 557–563, 1898.)—A spiral spring is suspended horizontally by a large number of threads, and is weighted by bullets. To each bullet is attached a weight by another thread. One end of the spring is driven by a metronome, and at a certain frequency there is no transmission of the wave motion. E. E. F.

1855. *Polarisation by Total Reflection.* **R. Geigel.** (Wied. Annalen, 68. 4. pp. 698–704, August, 1899.)—In ordinary cases of total reflection no polarisation of the emergent beam is noticeable. The author has, however, observed such polarisation by means of a hexagonal prism in which a beam is totally reflected a large number of times. Polarisation in the plane of incidence begins to appear after the forty-fourth reflection. The probable explanation is that the component normal to the plane of incidence emerges into the rarer medium and is lost. Light of all visible wave-lengths behaves in the same manner. E. E. F.

1856. *Molecular Rotatory Power.* **H. Pottevin.** (Journ. de Physique, 8. pp. 373–376, July, 1899.)—Pribram has shown that the rotatory powers of aqueous solutions of tartaric acid go on diminishing as we add progressive quantities of methylic, ethylic, or propylic alcohol, or of formic, acetic, or propionic

acid. The author finds that formic and ethylic aldehydes act in the contrary sense, and that the increases in the molecular rotatory power depend not only upon the relative proportions of the aldehyde and the tartaric acid but also upon the proportion of water which is present. Formic aldehyde acts in the same dextrogyric sense upon sugars, upon left-handed amylic alcohol, and upon left-handed essence of matricaria (fever-few): it appears to have no influence upon essence of turpentine. A. D.

1857. *Optical Properties in an Electric Field.* **W. Voigt.** (Wied. Annalen, 69. 1. pp. 297–318, September, 1899.)—The author examines the Hertzian equations with a view of finding whether any electric effects analogous to Zeeman's magneto-optic effect can be predicted from them. When the field is regarded as dependent upon the presence of ponderable matter, and the field components are introduced in their lowest possible power, the formulæ yield the electro-optic phenomena observed by Pockels in acentric crystals, as well as the Kerr effect. For media with sharp absorption lines the formulæ indicate a definite influence of an electric field in the shape of doublings or displacements. Some remarkable converse phenomena also follow, such as the production of a constant electric field in acentric crystals, and a variation of the inductivities of centric crystals and of isotropic bodies by the action of light. E. E. F.

1858. *Intensities of Zeeman Components.* **W. Voigt.** (Wied. Annalen, 69. 1. pp. 290–296, September, 1899.)—The author attempts to find an explanation of the differences in the intensities of the components into which a simple spectrum line is split up in the Zeeman effect. The theory he gives involves an amplification of the Hertzian equations, the resistances opposing the oscillations of the vectors characteristic of each spectrum line being assumed to vary with the strength of field. This assumption also explains the appearance of previously unknown absorption lines when in the magnetic field, and Egoroff and Georgiewsky's observation of the partial polarisation of the light of a monochromatic flame which is viewed at right angles to the lines of force and not subjected to spectrum analysis. E. E. F.

1859. *Kerr Phenomenon.* **H. Abraham** and **J. Lemoine.** (Comptes Rendus, 129. pp. 206–208, July 24, 1899.)—Experiments on the gradual but rapid decay of the birefringence when the field is abolished. Disruptive discharges are used, and the light from the spark itself is examined through the Nicol. When the

spark is set at different distances the light has to traverse different lengths of path before it passes between the condenser plates where it is acted upon in the electric field. When the source of light is at a greater distance, more time has been allowed to enable the Kerr-phenomenon-producing condition to die away, and it is found that the electro-optic phenomenon is reduced to one-half in one 400,000,000th part of a second. A. D.

1860. *Spectra of Oscillating Discharges.* **G. A. Hemsalech.** (Comptes Rendus, 129. pp. 285–288, July 31, 1899.)—The author studies in detail the influence exerted by a self-induction in the discharge circuit upon the spectrum of an oscillating spark discharge. The first effect of the introduction of the self-induction is to lower the temperature, and thus eliminate the lines due to the surrounding gas from the spectrum of the spark. A table of the lines displayed by bismuth is given for three different values of the self-induction. In hydrogen under atmospheric pressure the lines due to the oscillating discharge are sharp, and this sharpness is not interfered with by the sparking distance. By employing 0·0038 henry the author has obtained lines which ordinarily only appear in Geissler tubes. E. E. F.

1861. *Red End of Argon Spectrum.* **C. Runge.** (Astro. Phys. Journ. 9. pp. 281–283, 1899.)—The author has recently been furnished with photographic plates specially sensitised for the region λ 7500, in the extreme red, and has obtained photographs of the argon spectrum with a concave Rowland grating of 1 metre radius, extending from λ 7207 to λ 8015. A table of the lines and relative intensities is given. C. P. B.

1862. *Structure of Hydrogen Lines in Solar Spectrum.* **L. E. Jewell.** (Astro. Phys. Journ. 9. pp. 211–213, 1899.)—The wave-length of Hδ, the blue line of hydrogen, has been given a certain value by Rowland in his table of standard wave-lengths, but this has been thought to be about one-tenth of an Ångström unit in error by some spectroscopists. The author of the present paper, who is responsible for the measurements from which Rowland's table is compiled, has remeasured the plates, and, finding no error in evidence, explains the discrepancy by the fact that the structure of the solar spectrum at this point has some effect on the position of maximum intensity which is chosen for the centre of the line. The measurements of hydrogen lines obtained during a solar eclipse or from a vacuum tube are not complicated by the presence of neighbouring lines, and thus a slight difference in *estimated* wave-length is possible. C. P. B.

1863. *Efficiency of Spectroscopes.* **H. C. Lord.** (Astro. Phys. Journ. 9. pp. 191–202, 1899.)—The difficulty involved in the mathematical analysis of the various combinations of optical systems for a spectroscopic train is in many instances complicated by the resulting integrals being indeterminate (directly). To lessen this the author has developed a graphic method whereby the curves corresponding to the integrals may be constructed by use of the planimeter, and consequently the comparison of various systems made with greater ease. The cases he discusses are: (1) a *bright* slit of angular width σ on a *dark* background; (2) a *dark* line of angular width σ on a *bright* background; (3) a slit of angular width σ illuminated by light of all except certain stated wave-lengths, viewed through a dispersive train (*e.g.*, the solar spectrum). The curves obtained are illustrated by actual examples calculated for well-known spectroscopes, and they show by inspection the relations existing between the slit width, aperture and focal length of lenses, and grain of photographic plate; so that, if one or more are varied, the effect on the performance of the instrument can be predicted to a certain extent. C. P. B.

1864. *Concave Grating Stellar Spectroscope.* **S. A. Mitchell.** (Astro. Phys. Journ. 10. pp. 29–39, June, 1899.)—A short account has previously been given of the promise of Rowland's concave gratings in the photography of stellar spectra (Astro. Phys. Journ. 8. p. 157, March, 1898), and the present paper gives the results obtained with apparatus specially designed for the purpose. The usual method of working with the concave grating is to mount slit, grating, and camera on the circle having its radius equal to half the radius of curvature, but this would necessitate the employment of a subsidiary telescope to project an image on the slit. In the direct method adopted the slit is dispensed with, and the light from the star, after diffraction and reflection from the grating surface, is brought to focus on a curve situated about half the radius of curvature from the grating. The spectrum for a short distance on either side of the axis is practically normal. The grating used has a radius of curvature of *one* metre, and is ruled with 7,219 lines to the inch, the ruled surface having an area $2 \times 5\frac{3}{4}$ inches. This was mounted on the $9\frac{1}{2}$-inch Hastings refractor, and although this is on the sixth floor of a building in Baltimore, excellent results have been obtained. Later the grating was used at the Yerkes Observatory. The lines are adjusted parallel to the equator, so that errors of the driving clock will not spoil the definition of the spectrum lines. As the light passes through neither object-glass nor prisms, there is little absorption of the ultra-violet region. The photographs in the *first* order were $1\frac{1}{4}$ inches long from $H\beta$ (λ 4861) to the extreme ultra-violet, and usually both first and second orders were obtained on one plate. The hydrogen series in such stars as Sirius is specially

well shown, twenty-one lines being identified on one plate. Of special interest are the results of two plates obtained of the spectrum of the Orion nebula with exposures of about $3\frac{1}{2}$ hours, the wave-lengths of twenty-nine lines being given in the article. A method of using the grating so as to give absolute wave-lengths for work on motion in the line of sight is also given, and a *résumé* of the advantages of using concave gratings. C. P. B

1865. *Spectroscope of Fixed Deviation.* **P. Pellin** and **A. Broca.** (Paris, Soc. Phys. Séances, 1899, 1. pp. 24–29.)—A paper similar to that referred to in Abstract No. 1480 (1899). EDITOR.

1866. *Becquerel Rays.* **J. Elster** and **H. Geitel.** (Wied. Annalen, 69. 1. pp. 83–90, September, 1899.)—The authors have made another attempt to discover the origin of Becquerel rays, but again without success. Thinking that the radiation might be influenced by the impact of kathode rays, they exposed a piece of pitch blende from Joachimsthal to kathode radiation, and determined whether that produced any difference in the Becquerel rays. It did not. Nor could any influence of temperature be demonstrated. The authors believe the Becquerel rays to be Röntgen rays of small intensity, and they render this very probable by two further analogies which they have discovered. A magnetic field not only increases the resistance of a partial vacuum, but it also retards the discharge of an electrified body provoked by the impact of either Röntgen rays or Becquerel rays. An obvious explanation would be that the Becquerel rays are deflected by a magnet; but when the rays were made to produce a bright patch on a fluorescent screen no magnetic field could displace that patch. E. E. F.

1867. *Becquerel Rays.* **O. Behrendsen.** (Wied. Annalen, 69. 1. pp. 220–235, September, 1899.)—The author brings some further evidence in support of the identity of Röntgen and Becquerel rays. He found that the latter are capable of exciting fluorescence in a plate of fluorspar. He also definitely disproved the polarisation of Becquerel rays, which their discoverer had relied upon as a distinction from Röntgen rays. He obtained a highly active substance by sublimating powdered pitch blende. He calls this substance X-sublimate, and finds the radio-activities of uranium, pitch blende, and X-sublimate to be in the ratio of 1 to 8·47 to 52·24. Pitch blende shows a strong variation with temperature, in spite of Elster and Geitel's negative results. Cooling to $-50°$ produces a reduction of the activity. Heating to 100° increases the activity, but incandescence destroys it.

X-sublimate shows the same behaviour, and so does uranium, except that the increase on gentle heating is not so evident. The author believes that he succeeded in eliminating all sources of error, such as that due to convection. He does not believe in a complex atom, but favours the theory of unstable molecules.

E. E. F.

1868. *Radio-active Baryta and Polonium.* **F. Giesel.** (Wied. Annalen, 69. 1. pp. 91–94, September, 1899.)—The author has examined a large number of radio-active barium salts from de Haën's chemical factory. When crystallised fresh from the aqueous solution, they gradually increase in activity. After some days or weeks they reach a maximum, and after that the activity remains constant as long as the crystals are kept free from moisture. Even concentrated solutions of the salts have some activity, but that gradually disappears. The crystals first crystallised are the most active. The author has not succeeded in isolating the active element, whether radium or polonium. But by precipitation with sulphuretted hydrogen he has obtained a substance which exceeds the best barium salts in activity. The rays ascribed to polonium are more easily absorbed by metals than those ascribed to radium, and the former rays therefore yield better radiographs of the hand, &c., as they show more contrast. The author does not think that fractional crystallisation alone will yield more highly active substances.

E. E. F.

1869. *Polarised Fluorescence.* **G. C. Schmidt.** (Wied. Annalen, 68. 4. pp. 779–782, August, 1889.)—That uranium salts and certain solid solutions of aniline dyes in phthalic acid do not emit polarised fluorescence has been confirmed by the author by means of a new fluoroscope, in which the parallel beam from an arc lamp was changed into a convergent beam by a quartz lens, and was then allowed to enter the crystal under examination. A violet glass was placed in front of the lens. It transmitted the whole of the blue and violet, and a little of the red. The path of the beam through the crystal was observed from the side by means of a Nicol or a dichroiscope. Among the crystals thus investigated were the uranyl compounds of sodium and potassium acetates, and of ammonium nitrate. None of these showed any polarisation in their fluorescent light. Glass under pressure, which shows double refraction, failed to show polarised fluorescence. Uranium glass gave equally negative results, and so did carbon bisulphide containing a little chlorophyll, which shows a brilliant red fluorescence. Sohncke's rule, according to which the fluorescence of all bi-refracting crystals is polarised, has therefore several pronounced exceptions.

E. E. F.

1870. *Diffraction of Röntgen Rays.* **M. Maier.** (Wied. Annalen, 68. 4. pp. 903–916, August, 1899.)—This is a series of experiments made to determine the "wave-length" of Röntgen rays by means of diffraction. In the absence of regular reflection and of polarisation, the diffraction method is the only one available, and that method has not yielded anything like consistent results except in the hands of Fomm. The latter used a linear source of Röntgen rays, a slit parallel to it, and a screen behind the slit, on which he detected two systems of fringes, one on each side of the image of the slit, and one system in the image itself. The author, in endeavouring to repeat this experiment, used every variety of focus tube and altered the elements of the arrangement in every conceivable manner, but without success. It was only when he had recourse to ordinary Crookes or Hittorf tubes that he obtained the fringes sought, or rather the first minimum within the image. The distance between the line of light and the slit was 200 mm., between the slit and the screen 180 mm., and the width of the slit was 0·1 mm. The resulting wave-length was 15 $\mu\mu$ consistently with two tubes. That would be about $\frac{1}{30}$ of the wave-length of ordinary light, and that value agrees well with that obtained by Fomm, though it remains to be proved that we are dealing with true diffraction. E. E. F.

1871. *Diffraction of Röntgen Rays.* **H. Haga** and **C. H. Wind.** (Wied. Annalen, 68. 4. pp. 884–895, August, 1899.)—The "interference fringes" produced by Röntgen rays in Fomm's experiment, and used by him for determining the wave-length of Röngten rays, are, according to the authors, nothing but a hitherto unknown optical illusion. That they are not diffraction fringes is shown by an experiment with a tapering slit, which produces two fringes representing Fomm's "first minimum." The fringes run alongside the two edges of the image of the slit, but always keep parallel to them, instead of diverging from them in the narrower portions. They eventually cross. The illusion is produced along the edges of penumbra. The edge of the geometrical image appears brighter where the penumbra begins, and of course darker on the negative. Hence the dark fringe. This reasoning does not, of course, explain away Fomm's system of fringes, but they are doubtful in any case. The authors do not reject the possibility of Röntgen rays producing diffraction phenomena, and they describe, in fact, a curious periodic broadening of a tapering slit image, which would indicate a spectrum consisting of several bands in the very extreme ultra-violet. But the wave-length guessed at is only of the order of 0·1 $\mu\mu$. E. E. F.

HEAT.

1872. *Thermometric Corrections.* **F. Grützmacher.** (Wied. Annalen, 68. 4. pp. 769–775, August, 1899.)—The author describes the process of thermometer testing adopted at the Reichsanstalt. All temperatures between 0° and 100° are now reduced to the international hydrogen scale. At higher temperatures the air thermometer is retained as a standard, since comparisons between that and the hydrogen thermometer are not completed yet. Within the limits mentioned the discrepancy between the two gas thermometers does not exceed 0·011°.

E. E. F.

1873. *Air Thermometer.* **L. Holborn** and **A. Day.** (Wied. Annalen, 68. 4. pp. 817–852, August, 1899.)—In the construction of gas thermometers for use at high temperatures, either porcelain or platino-iridium may be used as a material of the vessel. The authors decide on the whole in favour of the platinum alloy. Hydrogen passes freely through incandescent platinum, but nitrogen does not, and the nitrogen pyrometer is reliable up to 1,300°. The porcelain cylinder suffers under various drawbacks. It is not gaslight unless it is glazed, and the glaze begins to melt at 1,100°. At 1,450° the porcelain itself softens, and the vessel is filled with vapour given off by the glaze. The authors use a saltpetre bath for producing temperatures up to 750°, and a zinc bath up to 900°. Beyond that they heat by means of an electric current, since at the highest temperatures flame gases pass through the walls of the vessel. They determined the coefficient of expansion of the platinum alloy used with great accuracy.

E. E. F.

1874. *Measurement of Temperature and Pressure.* **K. Scheel.** (Zeitschr. Instrumentenk. Beib. 9. pp. 69–72, 10. pp. 81–84, 11. pp. 89–92, 12. pp. 101–104, 13. pp. 109–111, 1899.)—This paper is a short history of the methods used for measuring temperatures and pressures, and especially of the latest developments. To render the mercury thermometer an exact instrument, at the suggestion of the *Bureau International*, a large stock of a certain quality of glass (*verre dur*) was obtained by Tonnelot, of Paris, and out of it a number of thermometers have been constructed. These, when systematically studied as to calibration and change of zero point, are found to give readings in accordance to two or three thousandths of a degree. The scale of temperature thus arbitrarily defined was compared with that of the hydrogen thermometer. In Germany the same object was attained in a more complete manner by determining the chemical composition and mode of manufacture of certain

glasses suitable for thermometer-making; these are Schott & Co.'s "Normal thermometer glass," 16^{III} and a borosilicate glass 59^{III}, both of which show very small depressions of the freezing-point; the latter only 0·05° for the interval 0° to 100°. The latter glass is now almost exclusively used for thermometer-making, and some 370,000 thermometers have so far been tested in the German testing laboratories. Glass 59^{III} has such a high melting-point that it can be used for making thermometers to read up to 550°, the glass showing no signs of softening at that temperature. In order to prevent the mercury from boiling, the tube above the mercury is filled with carbon dioxide under high pressure, taken direct from a bottle of liquid carbon dioxide; the tube is then temporarily shut off by melting a little plug of shellac into the capillary, and under protection of this is fused off.

For low temperatures toluene has been found the most appropriate liquid to use; its scale has been compared with that of the gas thermometer. Lately Kohlrausch has adopted petroleum ether for the same purpose, as it remains liquid down to −200°, although somewhat viscous. For still higher and lower temperatures, either a platinum resistance thermometer or a thermo-couple is employed. The latter, which seems to be preferred in Germany, is made of Pt and Pt with 10 per cent. Rh (Le Châtelier's combination), the wires being about 0·6 mm. thick and 1·5 m. long, welded together at the ends, and enclosed in a porcelain tube for protection from furnace gases. The thermo-couple is available up to 1,600°; it has been compared with the gas scale, and temperatures up to 1,000° may (it is claimed) be measured to within 5°.

A description follows of certain mercury manometers, including those of Cailletet and Amagat for high pressures, and a less known form, the "broken" manometer, for attaining high pressure without the use of a great vertical height. Such an instrument has lately been adopted by the Reichsanstalt, and consists of twenty glass tubes, each two metres long, mounted side by side, and connected alternately at the top and bottom; the lower half of each tube is filled with mercury, the upper half with water, so that when pressure is applied to one end the mercury rises in all the even tubes and falls in all the odd ones. The twenty menisci are read by a mirror scale, and give the measure of the pressure. The glass tubes will stand 200 atmos. pressure; the maximum error is given as 0·02 atmos.

For high pressures the Reichsanstalt has adopted a piston manometer essentially similar to that of Amagat, the pressure being balanced by weights on a piston of measured diameter. This at 20 atmos. gave a reading 1/500 different to that of the mercury manometer. R. A. L.

1875. *Calorimetry.* **S. Lussana.** (Rivista Scientifica, 30. pp. 176–183, 1898.)—A calorimetric apparatus is described which is on the lines of that used by Fabre and Silbermann, but is so arranged that the calorimeter may be brought to and maintained at a temperature higher than the external temperature, while the substance to be studied may be maintained at a temperature equal to the external. A. D.

1876. *Conditions of Sensitiveness of the Thermopile and Bolometer.* **H. C. Pocklington.** (Cambridge Phil. Soc. Proc. 10. pp. 66–71, June 7, 1899.)—In the bismuth-antimony thermopile the bars should be 2 metres long and their cross-sections should be as 2·56 to 1; with the ordinary length of 2 cm. and this ratio of cross-sections the sensitiveness is greatest, and about one-fifth of the theoretical maximum, if the resistances of the thermopile and galvanometer are as 1 to 1·091. With the bolometer the galvanometer should have the same resistance as the strip, and the arms which are attached to the contacts of the strip with the galvanometer and battery should be respectively as large and as small as possible. If one of these arms is made with resistance equal to that of the strip, as is usually the case for practical reasons, the resistance of the galvanometer must be half or twice that of the strip, as the case may be, and the sensitiveness is less than the maximum by about 29 per cent. R. E. B.

1877. *Pressure, Volume, and Temperature in Fluids.* **E. H. Amagat.** (Journ. de Physique, 8. pp. 353–362, July, 1899.)—In the expression $(p+\mathrm{P})\ (v-a)=\mathrm{RT}$, if we use, instead of P (the internal pressure), the quantity $\pi=\mathrm{W}\,3v=\Sigma r\phi(r)\,3v$, where W is the virial of the interior forces, we obtain the simplified expression—

$$\left(p+\frac{\Sigma r\phi(r)}{3v}\right)v=\mathrm{RT},$$

in which the co-volume a disappears. Attention might then be confined to this term π; and discussion of the experimental results leads to the expression given in Abstract No. 1007 (1899). Applications to saturation conditions are discussed. R is slightly higher than $273^{-1}=0{\cdot}003663$; because at zero, when $p=1$ and $v=1$, the expression becomes $1+\pi=\mathrm{R}\times 273$ and π can only become $=0$, so as to make the expression $\mathrm{R}\times 273=1$, by referring to the mass of the gas at a vanishingly low pressure. But this is the aim that should be kept in view, so as to maintain the consistency of the thermodynamic equations; and if the zero isothermal is prolonged to the axis of pv, and if with the unit mass of gas as above defined it gives $(1+\varepsilon)$ as the value of the ordinate p_0v_0 instead of 1, then the true unit mass referred to should be that unit divided by $(1+\varepsilon)$. A. D.

1878. *Rectilinear Diameters and the Laws of Corresponding States.* **E. Mathias.** (Journ. de Physique, 8. pp. 407–413. August, 1899.)—If a fluid has a rectilinear diameter, its densities δ and δ' in the saturated states of liquid and vapour at any absolute temperature T are connected by a relation of the form—

$$\tfrac{1}{2}(\delta+\delta') = A - BT,$$

where B is the tangent of the slope of the diameter and A is another constant for the substance, given by $A = \Delta + B\Theta$, Δ and Θ being the critical density and absolute temperature. Thence follows at once—

$$B\Theta/\Delta = \{(\delta+\delta')/2\Delta - 1\}/(1 - T/\Theta) \equiv a,$$

and if the substance belongs to a group which conform to the laws of corresponding states this quantity a must be constant for the group. Now a is shown by observation to vary from 0·68 for nitrogen to 1·09 for ethyl propionate and not to have the same value even for the different members of a homologous series: hence the laws of corresponding states do not rigorously apply to rectilinear diameters except possibly in the neighbourhood of the critical states.

Amagat's procedure is unsatisfactory; for though it leads to a correct value of the critical density of ethylene, it gives one for ether which is 40 per cent. in defect of that deduced from experiment. R. E. B.

1879. *Specific Heat of Water.* **H. L. Callendar** and **H. T. Barnes.** (Electrician, 43. pp. 775–778, September 22, 1899. Paper read before the British Association, 1899.)—A current of water flowing through a fine tube is heated by an electric current through a platinum conductor in the axis of the tube, convective and radiative losses of heat being diminished by a vacuum jacket, with its external surface kept at the temperature of the inflowing water. When the steady state has become established the mass of water M that passes through the tube in a given time t is determined, and also the resulting rise of temperature $\delta\theta$ (by means of a differential platinum thermometer reading to 0·001° C.), the current through the conductor C, and the difference of potential E of its ends. H being the very small external loss of heat, the specific heat (in mechanical units) of water at its mean temperature in the tube J is given by—

$$JM\delta\theta = ECt - H.$$

The experiments extended from 0° to 60° C., $\delta\theta$ being generally from 8 to 10° and M about 500 grammes, and, on the assumption that at 15° C. the E.M.F. of the Clark cell is 1·4342 volts, the resulting

formula (in joules per gramme per C. degree) for this range of temperature was—

$$J = 4{\cdot}181\{0{\cdot}9982 + 0{\cdot}0000045\ (\theta - 40)^2\}$$
$$= 4{\cdot}174 + 0{\cdot}00001881\ (\theta - 40)^2,$$

showing the minimum value to occur at 40° C. and the increase in J to be very rapid on approach to 0° C.

An interesting discussion of the results of other experimenters is given, and also reasons for provisionally taking for the range from 60° to 220° C. the formula—

$$J = 4{\cdot}181\ (0{\cdot}9944 + 0{\cdot}00004\ \theta + 0{\cdot}0000009\ \theta^2),$$

which represents Regnault's values diminished by a constant quantity. R. E. B.

1880. *Dilatation of Porcelain.* **T. G. Bedford.** (Electrician, 43. p. 780, September 22, 1899. Abstract of Paper read before the British Association, 1899.)—The linear expansion of Bayeux porcelain with rise of temperature is found to be represented fairly well by the formula—

$$l/l_0 = 1 + 0{\cdot}000003425t + 0{\cdot}000000000107t^2$$

between 0° and 600° C., and the results found for higher temperatures up to 830° C. do not depart far on either side from this curve. Reading microscopes were used to determine lengths, and temperatures were measured by the resistance of a platinum wire. R. E. B.

1881. *Dilatation of Iron and Steel at High Temperatures.* **H. Le Chatelier.** (Comptes Rendus, 129. pp. 331–333, August 7, 1899.)—The expansions were determined from the tilting of a cast-silica mirror owing to the unequal expansion of its two supports, one of Sèvres porcelain and the other of the body studied. Three periods are to be distinguished, viz., the range of temperatures in which molecular transformations occur and the temperatures respectively lower and higher than this range.

Cast iron containing 0·057 per cent. of carbon and six steels containing percentages of carbon ranging from 0·205 to 1·21 were examined. I. At *low* temperatures their coefficients of expansion are sensibly identical, being about 0·000011 at ordinary temperatures and increasing regularly to 758°, where their value is about 0·000017. II. At *high* temperatures the expansion-coefficients

increase rapidly with the percentage of carbon, being 0·000015, 0·000017, 0·000022, 0·000029 for the percentages 0·057, 0·205, 0·84, 1·21. III. For the range of transformation the observations were not satisfactory; but for the percentages of carbon 0·057, 0·205, 0·49, 0·84, 1·21, for which the mean temperatures of transformation were 840°, 768°, 728°, 730°, 725°, the contractions observed were 0·0026, 0·0023, 0·0021, 0·0008, 0·0010. A great number of the anomalies observed are explicable on the assumption that there occur, with more or less relative retardation, (i.) a molecular transformation of the iron, accompanied by a contraction of 0·0026, (ii.) the solution in this transformed metal of the iron carbide Fe_3C, accompanied by an expansion which would also be 0·0026 for a 0·09 percentage of carbon. R. E. B.

1882. *Kinetic Theory of Liquids.* **W. Voigt.** (Wied. Annalen, 69. 1. pp. 324–326, September, 1899.)—This is a reply to Jäger's criticism (see 1899, Abstract No. 1694) of the author's work. The author points out that he does not adopt rigid spheres as his atomic units, but "impact spheres" (*Stosskugeln*) defined as spheres constructed about molecules such that the centre of gravity of another molecule cannot penetrate into the sphere without experiencing a deflection. E. E. F.

SOUND.

1883. *Theory of Wind Instruments.* **F. Larroque.** (Comptes Rendus, 129. pp. 95–98, July 10, 1899.)—The tubes of brass instruments consist of a conical part with its vertex at the mouth of the player, and an enlarged portion at the further end. The effect of the enlarged end is to emphasise the higher harmonics. For the pitch of the note emitted is not altered if the cone is continued in its regular shape to the end of the tube. The portions situated between the cone and the brass resound to the notes produced in the tubes, and strengthen them while increasing the expenditure of wind. An increased expenditure of power implies an increased prominence of the overtones. E. E. F.

1884. *Beats of Strings.* **C. Maltézos.** (Comptes Rendus, 129. pp. 438–439, August 28, 1899.)—A mathematical theory of the vibration of strings indicates that the number of beats is proportional to the square root of the section, inversely proportional to the cube of the length, and inversely proportional to the root of the tension. Experiment shows, however, that the law of length does not hold good, the number of beats heard being nearly inversely proportional to the length. The author therefore concludes that his theory is not complete, and that the beats in a single string are probably due to a difference of elasticity in two directions across the sectional area. E. E. F.

1885. *High Pitches.* **F. A. Schulze.** (Wied. Annalen, 68. 4. pp. 869–883, August, 1899.)—The mathematical theory of Quincke's interference method of measuring high pitches is developed and its practice described. The author converts it into an objective method by closing the mouth of the tube with a cork carrying a small plate of mica on which sand is strewn. When the tones traversing the two branches of the Quincke tube coalesce to a maximum the grains of sand are projected upwards some 5 mm. The author verifies Stumpf and Meyer's criticism of Appunn's small tuning-forks. E. E. F.

ELECTRICITY.

1886. *Ribbon and Dark Lightning.* (Nature, 60. pp. 423–424, August 31, 1899.)—This article is illustrated by a reproduction of a photograph of lightning taken at Devonport (Tasmania) which shows a broad or ribbon-like flash with several dark ramified flashes. It is suggested that to obtain information as to the reason of the ribbon appearance systematic attempts should be made to photograph lightning with cameras having a known rate of movement, and an arrangement for determining the angular diameter of the ribbon. The dark flashes spreading from the main bright one are attributed to photographic reversal of previous bright flashes. Photography is thus held to give no support to the view that dark lightning has a real physical existence, and the letters from Lord Kelvin (August 10th) and W. J. Lockyer (August 24th) show that, when visually observed, dark lightning is an effect due to fatigue of the retina. E. H. B.

1887. *Electric Charge of Electrolytic Gas.* **W. Kösters.** (Wied. Annalen, 69. 1. pp. 12–33, September, 1899.)—The author attempts to determine the causes of the electrification of gases evolved by electrolysis. For this purpose he passed several such gases in the nascent state through liquids, and studied the power thus acquired of producing an electrometer deflection. Both hydrogen and oxygen were positively electrified by passing through sulphuric acid, just as they are when given off by the electrolysis of that acid. But oxygen from an oxygen tube, passed through a solution of caustic potash, showed positive electrification, whereas electrolysis of the same solution yields negatively electrified oxygen. The author considers that this points to the identity of the electrification observed on blowing through with what Lenard calls "waterfall electricity." Another peculiar phenomenon, first observed by Townsend, is that hydrogen, developed by electrolysis of dilute hydrochloric acid with platinum electrodes, is positively electrified, whereas its charge becomes negative after a while when carbon electrodes are used. E. E. F.

1888. *Loss of Electric Charge by Evaporation.* **H. Pellat.** (Paris, Soc. Phys. Séances, 1899, 1. pp. 14–24.)—A paper similar to those referred to in Abstracts Nos. 562 and 1375 (1899).
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1889. *Disruptive Discharge.* **W. de Nikolaieve.** (Journ. de Physique, 8. pp. 432–433, August, 1899.)—To determine the precise effect of a disruptive discharge upon the intervening air, the author places a layer of cotton-wool, pressed between two ebonite rings, in the path of the spark. After the spark has passed, it is found that the cotton-wool is traversed by a canal about 6 mm. wide, with sides consisting of compressed cotton-wool. Soaking the cotton-wool in water or in vaseline oil enlarges the canal, but produces no essential difference in its structure. Sheets of aluminium or copper introduced in the path of the spark show depressions, which on microscopic examination are found to contain congealed droplets of the metal. E. E. F.

1890. *Genesis of the Electric Spark.* **B. Walter.** (Wied. Annalen, 68. 4. pp. 776–778, August, 1899.)—The author has collected some further evidence to show that every spark discharge is preceded by several tentative brush discharges which proceed from both electrodes. The positive brush is four or five times the length of the negative brush, and is much branched. There is a thickening in the central portion of the spark not covered by previous brushes, evidently due to an accumulation of energy in the central region. Even the final spark is not homogeneous, as is seen by a faint bridge which sometimes crosses a curved portion. E. E. F.

1891. *Pressure within the Spark.* **E. Haschek** and **H. Mache.** (Wied. Annalen, 68. 4. pp. 740–751, August, 1899.)—That the sudden increase of pressure produced by a spark is not due to its heat is proved by its subsidence immediately on the cessation of the spark, and by its magnitude, which may amount to 16 mm. in a pressure of 56 mm. The authors have arrived at what they believe to be a close estimate of the pressure within the spark itself. Having obtained an idea of the actual dimensions of the spark by photography, they measured the increase of pressure per unit surface of the vacuum tube by a specially constructed manometer. By reducing the total increase of pressure to the surface of the spark the pressure within the latter was obtained. In the case quoted it was 11·3 atmospheres. It was found to increase with the energy, the pressure of the gas, and the sparking distance. The authors point out a similar increase of pressure when an arc light is established. They believe the pressure to be intermittent, and estimate it at 2 to 3 atmospheres. They attribute the pressure in both cases to particles projected from the electrodes. It is higher in sparks between carbon electrodes than between electrodes of iron, zinc, or other metals. E. E. F.

1892. *Work Consumed in a Spark-Gap.* **E. Riecke.** (Wied. Annalen, 68. 4. pp. 729–739, August, 1899.)—In the course of some work with a 40-plate Toepler machine, originally designed for experiments on vacuum discharges, the author had occasion to determine the work expended in spark-gaps of different lengths. The influence machine was driven by a motor provided with a speed indicator. The voltage, current strength, and speed were taken with and without the spark-gaps. With a constant speed of 13 turns per second the watts per turn were found to be, for various lengths of gap—

Gap 2 cm.	1·64	watts	.....	Heat	4·96	grm.-cal. per sec.
„ 4 cm.	2·08	„	.....	„	6·05	„ „
„ 6 cm.	3·27	„	.....	„	9·56	„ „
„ 8 cm.	1·79	„	.....	„	5·39	„ „

An interesting result brought out by the above table is that the work diminishes as the spark-gap is widened from 6 cm. to 8 cm. Since the difference of potential increases at the same time, it follows that the quantity of electricity discharged is a good deal less, and that is obvious from the appearance of the sparks. The author endeavoured to confirm the above results by substituting tubes filled with cadmium iodide solution for the spark-gaps. The results were then somewhat higher. E. E. F.

1893. *Conduction in Rarefied Gases.* **E. Bouty.** (Comptes Rendus, 129. pp. 152–155, July 17, and pp. 204–206, July 24, 1899.)—An isolated conductor (a flask) introduced between the armatures of a condenser actuated by a potential difference V, produces an increase in the capacity of the system, which is the same whether the flask be filled with a metallic substance (mercury) or an electrolyte, or whether its conductivity be due to a superficial film of moisture, inside or outside, and which is independent of the value of V. But a dry flask full of air produces only a trifling increase of capacity if the air be at the ordinary pressure: a non-conductor therefore acts differently from a conductor. Vacuum tubes act in this respect like air at ordinary pressure: the extremely rarefied air is a non-conductor, whatever the voltage. Geissler tubes (1 to 5 mm.) at moderate voltages act in the same way, but at high voltages their contents come to act as conductors (with a flash of light), and at certain intermediate critical voltages the tubes may act in one way or the other, according to surrounding circumstances not yet fully ascertained. These observations tend to tell against the idea of there being free ions or any electrolytic conduction at voltages short of those under which the electric elasticity of the gas breaks down. The relation between the electromotive force and the gaseous pressure is further examined in pp. 204–206. The general result is that the values of the electromotive force f corre-

sponding to given values of the pressure p are, with tubes of different forms and condenser plates at different distances, proportional to one another; that within the limits tried $f = A(1 + Bp + Cp^{-1})$; that the term in p^{-1} preponderates at very low pressures, as if the molecules only tended to weaken the ether at their own locations; that when they are near to one another their mutual action increases the cohesion proportionately to their number; that B appears to be independent of the nature of the gas; that C appears, with less certainty, to be the same; that A increases somewhat with the molecular weight (1·00 for H, 1·55 for CO_2); and that if we measure p in millimetres of mercury, $B/C = 4·4$. A. D.

1894. *Gaseous Conduction in Incandescent Lamps.* **J. Stark.** (Wied. Annalen, 68. 4. pp. 919–948, August, 1899.)—The fact that flame gases have considerable electric conductivity leads to the inference that the hot gases in the bulb of an incandescent lamp may be partly instrumental in conveying the current through the lamp. This is made very probable by the author's observation that the current can be tapped by inserting metallic electrodes in the bulb, which are not in contact with each other nor with the filament. The current through the gas is subject to deflection by a magnet. There is a well-marked difference in the behaviour of a glowing carbon filament when charged positively and when charged negatively. A negative charge is dissipated more easily than a positive one. This explains the difference in the attraction exerted by differently charged bodies upon the glowing filament. It also explains the unidirectional character of the tapped current through the inserted electrodes. The temperature of the filament is about 1,500° C. At that temperature the gas still acts more as a dielectric than as a conductor; but at 2,000° C. all gases are probably conductors, and then we have practically an arc lamp. E. E. F.

1895. *Conductivity of Gases exposed to Discharge Rays.* **J. J. Thomson.** (Cambridge Phil. Soc. Proc. 10. pp. 74–77, June 7, 1899.)—The properties of discharge-rays, or "Entladungs strahlen," were discovered and described by E. Wiedemann and Hoffmann (see Physical Society's Abstracts, 1897, No. 208). They emanate from a region through which an electric discharge is passing: they move in straight lines, are not deflected by a magnet, and are stopped by solids, liquids, and some gases, such as carbon dioxide. Their effect upon the electric conductivity of gases exposed to them is studied in the present series of experiments. The discharge is produced between two electrodes, which can be moved along the axis of a tube, keeping the distance between them constant. From the side of this tube an opening, closed by wire gauze, leads to another tube at right angles to the first,

and has itself a lateral tube near its centre. Two aluminium cylinders with insulated wires along their axes are placed in these tubes in such a manner that one can be reached by a rectilinear path from the electrodes, while the other cannot be so reached. The author studies the rate of leakage of electricity between each cylinder and its axial wire for various pressures of contained air, and for exposure to different parts of the discharge. He finds that the Entladungs strahlen produce conductivity of the gases through which they pass, and that the effect is greater in hydrogen, and less in carbon dioxide, than in air. The radiation is emitted more copiously from the neighbourhood of the electrodes than from the rest of the spark: it appears therefore to be connected with the ionisation of the gas and its recombination. These phenomena are compared with the production of secondary rays when a gas is exposed to Röntgen radiation in which ionisation is taking place, and when Röntgen rays fall on a metallic surface; they are probably due to pulses arising from the sudden stoppage of the electrified ion. By bringing the gas experimented upon very near to the arc, and taking special precautions to prevent convection from the arc to the gas, the effect can be observed in air at ordinary pressure. J. L. H.

1896. *Motion of a Charged Ion in a Magnetic Field.* **J. J. Thomson.** (Cambridge Phil. Soc. Proc. 10. pp. 49–52, June 7, 1899.)—This treats of the motion of an electrically charged particle in a magnetic field, when the free path of the particle is so short that the effects of collisions form a dominant factor. The problem in hand is therefore complementary to the case of the kathode rays, in which the free path is so long that the effects of collisions are not appreciable. In the latter case the *acceleration* of the charged particle is, as usual, proportional to the force acting on it, but in the former case the *velocity* of the particle is proportional to the acting force. Starting from this ground, expressions are easily found for the components of the velocity of the charged particle, from which it appears that in a weak magnetic field the particle moves along a line of electric force, whereas in a very strong magnetic field the particle follows a line of magnetic force. In the general case there are component forces (1) along the line of electric force, (2) along the line of magnetic force, (3) in a direction at right angles to these lines. In this case, therefore, the path of the particle is a spiral.

These results show that, if we consider ions moving with different speeds in a magnetic field of constant strength, those ions which move at high speeds will travel along the lines of magnetic force, while those which move at lower speeds move along spirals. Now in the discharge of electricity through gases the velocity of the negative ion has always been found to be greater than that of the positive ion, and this difference of velocity

has been shown to account for many of the differences between the phenomena at the positive and negative electrodes in a vacuum tube. In like manner the foregoing considerations account for the difference in behaviour of the negative glow and of the positive column in a magnetic field. In a strong magnetic field the negative glow follows the lines of magnetic force, whereas the positive column on the other hand does not do so, but follows a more or less spiral path, and this is what is indicated by the above theoretical considerations. T. P.

1897. *Hittorf's Dark Space.* **H. Ebert.** (Wied. Annalen, 69. 1. pp. 200–219, September, 1899.)—Hittorf's dark space is the narrow space immediately adjoining the luminous layer covering the kathode itself. As exhaustion proceeds, this layer increases in thickness. The author investigates the relation between the thickness of the layer and the exhaustion, and shows that the dark space increases in a geometrical series as the pressure decreases in another geometrical series, usually of different index. The relation may be put in the form—

$$\frac{d_1}{d_2} = \left(\frac{p_2}{p_1}\right)^m$$

In oxygen, a discontinuity occurs at a pressure of 0·7 mm., the point at which also a discontinuity occurs in the same gas as regards Boyle's law. E. E. F.

1898. *Diffusion of Kathode Rays.* **W. Kaufmann.** (Wied. Annalen, 69. 1. pp. 95–118, September, 1899.)—The absorption and diffusion of kathode rays by gases as observed by Lenard is studied by Perrin's electrical method. A beam of kathode rays emerging from a vacuum tube was made to traverse a metallic cylinder earthed through a galvanometer. Beyond the cylinder the rays impinged upon a metallic plate earthed through another galvanometer. Any current indicated by the first galvanometer would then be due to kathode rays absorbed or diffused in the cylinder. According to the results of Lenard, taken in conjunction with the author's own results, only a very small portion of the current is accounted for by absorption. The author finds that the quantity $\frac{bV}{p}$ is constant for any given gas, b being the diffusion, V the difference of potential, and p the pressure. It is 5,650 for nitrogen, 6,830 for CO_2, 6,380 for CO, and about 730 for hydrogen.

The author goes on to investigate the probable mechanism of the kathode rays. He concludes that the energy given off by the particles constituting them is only partly converted into

kinetic energy of the gas molecules, leading to a rise of temperature, and that the other part is converted into oscillating motion of Prout's primitive atoms. The mass of such a primitive atom would be 0·038 (H=1), and that of a radiant particle 0·00053. The hydrogen atom would thus consist of about twenty-six primitive atoms. E. E. F.

1899. *Mechanics of Kathode and Canal Rays.* **P. Ewers.** (Wied. Annalen, 69. 1. pp. 167–199, September, 1899.)—In determining the ratio *e/m* of the electric charge to the mass of an ion, a decided difference appears between the canal rays and the kathode rays. Whereas in canal rays the values of the ratio are quite in accordance with the supposition that projected atoms are at work, the behaviour of kathode rays does not admit that assumption. Either the mass projected would have to be 2,000 times smaller than a hydrogen atom, or an atom would have to convey a quantity of electricity 2,000 times as great as that which it is known to convey in electrolysis. The author has made a number of quantitative experiments tending to throw light on this subject. He does not share the prevalent opinion that canal rays consist of projected anode particles, since the quantity of electricity conveyed by them varies with the material of the kathode, but not with that of the anode. The author concludes that the canal rays consist of positive ions of the material of the kathode, but the matter thus conveyed to the wall is so small that it would require 288 hours of continuous working to deposit one milligramme of aluminium. About 11 to 18 per cent. of the energy supplied is given up by the canal rays in the form of heat. E. E. F.

1900. *Kathode and Canal Rays.* **O. Berg.** (Wied. Annalen, 68. 4. pp. 688–697, August, 1899.)—The author perforated the anode instead of the kathode, and obtained phenomena which are converse to those of Goldstein's canal rays, thus showing that rays from one electrode are propagated across gaps in the other. It remains certain, however, that the bulk of the work of transporting the electric charge falls to the kathode rays, and this is probably due to the fact that negative charges in a vacuum, as in the open air, are dissipated more readily than positive charges. There are other important differences. Anode rays are not capable of producing the brilliant phosphorescence obtained with kathode rays. They are, therefore, less noticed and less studied. They are not deflected magnetically to the same extent. According to Wehnelt, their direction is largely influenced by the position of the kathode, whereas kathode rays are not influenced by the situation of the anode. E. E. F.

1901. *Potential Gradient at the Anode.* **C. A. Skinner.** (Wied. Annalen, 68. 4. pp. 752–768, August, 1899.)—The potential gradient within the luminous layer immediately covering the anode is practically infinitesimal. Both Hittorf and Graham found that there was a sudden fall of potential at the anode, though not so great as that in Crookes' dark space. There is, in fact, a difference of potential between the metallic anode and the gas, amounting to, say, 20 volts. This difference increases to, say, 40 volts within the first few millimetres, but the point brought out clearly by the author is that no such increase takes place within the luminous layer immediately adjoining the anode. This luminous layer is usually 1 mm. or 2 mm. thick, and closely adheres to the anode. Another fact revealed by the author's experiments is that the greater the drop of potential at the anode, the less is the potential gradient near the anode, and the greater is the distance from the anode at which the gradient becomes constant. In other words, a great anode drop means a thick anode layer. The anode drop depends, of course, upon the gas, the pressure, and the material of the anode. Generally speaking, those metals furnish the greatest anode drop which exhibit the least difference of potential when used as kathodes. E. E. F.

1902. *Phillips' Phenomenon.* **G. W. Walker.** (Electrician, 43. pp. 602–604, 634–635, August 18 and 25, 1899.)—A mathematical investigation of the luminous phenomena in Crookes tubes described by Phillips (see 1899, Abstract No. 683). The author assumes the luminosity to be due to the collisions of negatively charged particles moving under the influence of the magnetic field. Before the magnetic field is excited the distribution of velocities will be according to Maxwell's law; but the magnetic field will give a spin to the particles, and the new distribution of velocities will cause a new arrangement of the atoms. It is shown that the gas will rotate like a solid body—a result announced independently by Kelvin; and the author investigates in what manner the gas so set in motion will, under the influence of viscosity, approach the uniform distribution of velocities in the magnetic field. The luminosity at different distances from the axis is calculated for successive stages in this process, and the results are in general agreement with the phenomenon as observed by Phillips. J. L. H.

1903. *Reflection of Hertzian Waves.* **L. De Forest.** (Amer. Journ. Sci. 8. pp. 58–71, July, 1899.)—Using an exciter which is a compromise between the Lecher and Blondlot forms, the author investigates the nature of reflection at the ends of wires arranged as in a Lecher system. He determines the end capacities for the wires with ends bare, with brass balls at the ends,

and under other conditions; the effect of bending the wires; the decrement of amplitude in the train of waves sent out; and also examines (with a coherer) the field near the wires for plane-polarised displacements. D. E. J.

1904. *Improved Lecher System.* **A. Righi.** (N. Cimento, 8. 4. pp. 34–36, 1898.)—The terminals of the exciting coil are attached to two vertical plates facing the secondary plates. The sparks of the exciter circuit pass between knots in contact with the primary plates. E. E. F.

1905. *Hertzian Oscillations.* **O. Murani.** (N. Cimento, 8. 4. pp. 36–44, 1898.)—An abstract of Murani's Istituto Lombardo paper, by Federico and Pasquini. The latter, in an additional note, confirm Murani's observation that Hertzian waves cannot be demonstrated by the coherer, since that responds to waves of all lengths. A node is shown at the mirror, and a constant deflection at any distance from it. E. E. F.

1906. *Dielectric Constants.* **W. D. Coolidge.** (Wied. Annalen, 69. 1. pp. 125–166, September, 1899.)—The author improves Drude's method of determining dielectric constants of bodies obtainable only in small quantities by introducing the condenser into the exciter circuit instead of the resonator circuit. This has the effect of considerably increasing the accuracy and sensitiveness of the method. The liquids studied included various acetates and benzoates, mixtures of ethyl ether, and chloroform, liquid chlorine, and other gases, as well as alcohol and water. The temperature coefficient of the dielectric constant of water is $-0{\cdot}432$ per cent. per degree at 17°, which is well in agreement with previous results. Water shows anomalous dispersion of electric waves, but alcohol shows no electric dispersion at all. E. E. F.

1907. *Deformation of Dielectrics.* **P. Sacerdote.** (Comptes Rendus, 129. pp. 282–285, July 31, 1899.)—The author derives the formulæ expressing the electric deformation of dielectrics from the fundamental principles of electricity and the conservation of energy. He shows that all deviations from these formulæ are due to experimental errors. He finds that dilatation is the same in all directions normal to the lines of force, whatever be the shape and size of the condenser. As regards the causes of the dilatation, the author seeks them in the elastic deformation due to the known electric forces, and in a change of molecular state

in the dielectric due to the ether disturbance. In gases the latter cause alone is at work, and brings about the electric contraction observed in them. E. E. F.

1908. *Polarisation of Dielectrics.* **F. Beaulard.** (Comptes Rendus, 129. pp. 149–152, July 17, 1899.) — According to Poisson's formula $\mu = \frac{1+2g}{1-g}$, where μ is the magnetic permeability, and g the ratio between the space actually occupied by magnetic particles (assumed spherical and of infinite permeability, disseminated throughout a non-magnetic medium) and the total volume of the substance. But in iron, if $\mu = 500$, g is greater than the maximum possible ratio $\pi/(3\sqrt{2})$. Maxwell pointed this out: Betti makes $k = (\mu - 1)/4\pi \{= 3g/4\pi(1-3g)\}$ instead of $k = 3g/\{4\pi(1-g)\}$; whence $\mu = (1-3g)^{-1}$; which gives possible values. Mossotti has applied the same order of ideas in electrostatic induction, K corresponding to μ; and Clausius has reached a result the same as that of Poisson, K replacing μ. Experiment shows that the Clausius and Betti formulæ equally well represent the facts. With mixtures of copper filings and paraffin, the specific inductive capacity *increases* as the proportion of copper is increased: this is contrary to the Maxwellian doctrine that it is zero for perfect conductors. **Potier** writes that the electromotive force at a point is equal to the sum of the electromotive forces which produce the currents of conduction and of displacement, and obtains the relation—

$$P = \frac{u}{c} + \frac{4\pi f}{K},$$

which for a conductor makes $K = \infty$. A. D.

1909. *Flow of Electrolytes through Partitions.* **F. T. Trouton.** (Electrician, 43. pp. 596-597, August 18, 1899.) — A beaker, pierced by a small hole, is placed in a second vessel, and both are filled with dilute acid. A lead plate in each serve as electrodes. When a current passes between the electrodes, the liquid rises in one or other of the vessels. Reversal of the current does not reverse the direction of the flow of the electrolyte. Any obstruction placed near the hole on one side or the other predisposes the level to rise on that side. At first the rate of rise is slight, but it increases, and the vessel from which the liquid is flowing is rapidly emptied, *i.e.*, the flow increases as the difference of level increases, and against the hydrostatic pressure. The action appears to be accompanied by an intermittent arc at the perforation, but this part of the phenomenon is not clearly described. The liquid is forced from the lower to the higher level by the formation of bubbles of vapour periodically at the

perforation, on the side where the hydrostatic pressure is least, that is towards the lower level. The direction of flow depends upon which side of the hole the bubbles are formed. If a more dilute acid is placed on one side, the vapour tension is greater on that side, the bubbles form there more easily, and the flow is towards the denser side. The flow is always towards the side where bubbles are formed with most difficulty. R. A.

1910. *Electrolytic Conductivity of Solids at High Temperatures.* **W. Nernst.** (Zeitschr. Elektrochem. 6. pp. 41–43, July 13, 1899.)—The conductivities of rods composed of different metallic oxides or mixtures of oxides is investigated at different temperatures. The heating is done in a small electric oven and the temperature is measured by a platinum — platinumrhodium couple.

The conductivity of pure oxides increases very slowly with the temperature and also remains relatively small, while that of mixtures of oxides is of very much greater magnitude. [No numerical figures are given.] In order to test the conductivity at much higher temperatures, the rods are heated to incandescence by a current sent through them. The temperature can then be only roughly guessed at. The conductivities of mixtures of oxides, especially of those of Mg, Si, Zr, and the other rare earths are then found to be very great, a conductivity equal to that of the best conducting sulphuric acid solution being measured. At first alternating currents were used, but later it was found that continuous currents could keep one of the rods incandescent for hundreds of hours, without causing any disturbing decomposition. That the conduction is electrolytic and not metallic is evidenced by a number of considerations.

The transparency to light of all the oxides used is opposed to metallic conductivity. The author considers this a crucial test in all cases and applies it to the electric arc, and to the deep blue solution of Na in liquid ammonia, to both of which metallic conduction has been ascribed.

Mixtures of coloured oxides such as those of iron and cerium show a wandering of colour towards the kathode. Rods which contain much magnesia show quite appreciable growths at the kathode due to the burning of the magnesium formed there. Rods which are kept incandescent by continuous currents for a time show decided polarity, the kathode being always less bright than the anode. This is due to the rod becoming richer in the conducting material (dissolved oxide) near the kathode and poorer nearer the anode, consequently offering a higher resistance to the current near the latter. This unequal distribution only results to a certain extent, as diffusion, which tends to equalise matters, introduces a stationary condition. J. B. H.

1911. *Measurement of Self-Induction.* **G. W. Patterson.** (Wied. Annalen, 69. 1. pp. 34–65, September, 1899.)—The author compares the efficiency of two different methods of measuring self-induction—that of Maxwell as improved by Rayleigh, and that of Oberbeck, in which the coil of known resistance and unknown self-induction forms one branch of a Wheatstone bridge, the coil of an electrodynamometer takes the place of the galvanometer, and a zinc inductor that of the battery. The Maxwell-Rayleigh method requires accurately known resistances, a good ballistic galvanometer, and a constant temperature. The accuracy of the resistances and the constancy of the temperature are not so essential in Oberbeck's method, but the latter requires a sensitive electrodynamometer of rather high resistance and low inductance, and a constant source of sinusoïdal E.M.F. Oberbeck's method has the advantage of being in a certain sense a null method, since two points of equilibrium must be obtained, one with a continuous and the other with an alternating current, corresponding to the two enduring and two ballistic deflections in the other method. On the other hand, a galvanometer is far superior to an electrodynamometer in sensitiveness when the latter contains no iron, and iron is excluded by the fact that its presence would make the self-induction a function of the current. In the case of very small self-inductions, the joulean heat developed renders the Maxwell-Rayleigh method inaccurate. E. E. F.

1912. *Conductivity of Lead Peroxide.* **T. Sundorph.** (Wied. Annalen, 69. 1. pp. 319–323, September, 1899.)—Peroxide of lead, when used as a coherer substance, decreases in conductivity under the impact of electric waves. In one experiment the current decreased from 8·5 to 5 milliamperes in twenty minutes. At the same time the amount of PbO_2 was slightly reduced, but the author gives no explanation of this reduction. He observed that whatever took place was confined to the neighbourhood of the two terminals, and that the positive pole became hotter than the negative pole. E. E. F.

1913. *Measurement of Resistance by Damping.* **R. H. Weber.** (Wied. Annalen, 68. 4. pp. 705–728, August, 1899.)—In measurements of the resistivity of bodies like copper-zinc alloys containing more zinc than copper, it is impossible to obtain the substance in a form suitable for testing by the ordinary methods, owing to the brittleness of the alloys of that composition. The author has, therefore, worked out a new method, in which the material can be used in the form of plates or thick cylinders. Either a magnet is made to vibrate over a disc made of the alloy, or a cylinder of it is made to oscillate in

a magnetic field. The damping produced by the induced currents forms a measure of the specific resistance, the logarithmic decrement being directly proportional to the conductivity. The accuracy is considerable, the errors not exceeding 0·7 per cent. in the case of alloys and amalgams. A further advantage of the method is that the material examined need not be subjected to strong mechanical manipulation such as is, for instance, involved in wire-drawing. A somewhat modified method consists in observing the deflection of the body in a rotating field. This is not quite so satisfactory, owing to the slipping of the zero, but it has the advantage of being suitable for electrolytes as well as for metals. E. E. F.

1914. *Insulation of Three-Wire System.* **J. Kollert.** (Elektrotechn. Ztschr. 20. pp. 179–180, 1899.)—The author gives a method of finding inferior limits of the insulation resistances of the three wires taken separately when a galvanometer of known constant is introduced between each wire separately and earth, and the current strength is observed in each case. E. E. F.

1915. *Influence Machine.* **W. R. Pidgeon.** (Phil. Mag. 46. pp. 564–567, 1898.)—This is a simple machine in which each sector is embedded in an insulator, with the exception of a brass contact knob. It therefore carries a double charge, and the machine is, for the same surface, four times as effective as a Wimshurst machine. E. E. F.

1916. *Wehnelt Interrupter.* **W. J. Humphreys.** (Phys. Rev. 9. pp. 30–40, July, 1899.)—As negative electrodes, sheets of lead, copper, amalgamated copper, and coils of copper wire may be used with equal success. As positive electrodes, platinum wire or foil may be used; but the larger the exposed positive surface, the more current is necessary, the less frequent are the interruptions, and the greater the intensity of the secondary discharge. The distance between the electrodes is practically unimportant, and their relative positions are unimportant provided that the gases formed at the positive electrode can be easily and quickly replaced by the electrolyte. The platinum wire forming the positive electrode is held in a tube of soft German glass, external contact being made by mercury within the tube; to prevent subsequent cracking, the platinum is sealed into the tube with a bead of blue enamel glass. After long use, that part of the platinum which is in the electrolyte becomes pitted and frosted; and the part in contact with mercury within the tube becomes very perfectly amalgamated. The

author ascribes the pitting to the action of electric discharges. Those electrolytes that conduct best give the best results with the interrupter, they also give the most vigorous action when their concentrations are such as to give the best conductivities at the temperature at which they are used. To prevent acid spray and change of bulk of the electrolyte, a layer of paraffin oil should be poured over the surface; the electrodes may be dipped in and out through the oil without hindrance to the efficiency of the interrupter. When there is no glow the current is not interrupted; but when there is no break there may still be a glow on a part of the anode, suggestive of brush discharges. Examined with a revolving mirror, the glow is seen to be intermittent with total absence of light at the intervals. The spectrum shows the lines of hydrogen and oxygen. Interruption is disturbed by a strong magnetic field; and may be completely stopped until the applied volts are increased. Increase of hydrostatic pressure lowers the frequency. The gases generated are different from those obtained by quiet electrolysis; there is a relatively small proportion of oxygen. As regards self-starting, if the voltage is just enough to work the interrupter the action begins wherever the circuit is closed; if the voltage is high, the electrode must be immersed before closing the circuit. The positive electrode has three stable conditions of activity: (1) the high-resistance stage, corresponding to very small currents; (2) quiet electrolysis; (3) the stage of regular interruption, corresponding to large currents. With very small self-induction, the action can only be obtained with very small anodes. Decrease in the self-induction causes increase in average current. For X-ray work the best results are obtained with an interrupter giving a frequency of about 300 per second; higher frequencies cause the tube to light up throughout. The author suggests that the action of the interrupter depends upon electrical discharges. The current first increases, on account of the self-induction, until the electrode is completely sheathed by a layer of gas, almost entirely oxygen. This gas abruptly breaks the circuit, and owing to the self-induction there is now an electrical discharge across the layer, giving rise to the glow, and at the same time decomposing some of the liquid. The sudden freeing of these gases and the heat of the discharge together produce an explosive effect; when this is over, the liquid falls back to its place, and the action is continued. R. A.

1917. *Wehnelt Interrupter.* **É. Hospitalier.** (Soc. Int. Elect. Bull. 16. pp. 248–255, 1899.)—This is a summary of the work done on the Wehnelt interrupter up to April last, together with a description of some original experiments. E. E. F.

1918. *Caldwell Interrupter.* **A. G. Cooke.** (Elect. Rev. 44. pp. 888–889, June 2, 1899.)—In the modified Wehnelt interrupter designed by Caldwell and Simon, the small orifices are gradually enlarged, the glass presenting a ground appearance. At the same time, acid is drawn through from the larger into the smaller partition. E. E. F.

1919. *Wehnelt Interrupter.* **H. T. Simon.** (Wied. Annalen, 68. 4. pp. 860–868, August, 1899.)—The form of interrupter described consists of a lead vessel filled with dilute sulphuric acid. An ordinary wide test-tube, attached to an ebonite lid, projects down into the acid. It contains a cylinder of sheet-lead, serving as a second electrode, and the bottom of the test-tube has several perforations about 1 mm. wide. In another form of the apparatus, a rectangular glass vessel is divided into two partitions by means of a thin plate of glass containing a few perforations. The two partitions contain electrodes identical in shape. In a third form, which, however, is of more theoretical than practical interest, the two vessels are joined by an inverted U-tube containing liquid nearly interrupted by a bubble at the top. The second type is that usually adopted. Slits may be substituted for the holes. The interrupter operates equally well for continuous and alternate currents, and interrupts both phases of the latter. It is not spoilt by the heat developed. E. E. F.

1920. *Instantaneous Contact-Maker.* **J. Haralson, Jr.** (Elect. World and Engineer, 34. pp. 83–84, July 15, 1899.)—A hard rubber disc is attached to one end of a shaft, the other end of which is attached to the shaft of the machine to be tested by means of a universal joint. A cast-iron ring is attached to the disc, and in an opening in this ring is placed a piece of steel spring embedded in fibre. This piece of spring is connected by a wire to a brass ring fitted over the hard rubber disc. A brush bearing on this brass ring is therefore in continuous connection with the steel spring. Another brush bearing on the cast-iron ring makes contact with the spring once in a revolution. To take a curve of E.M.F., the instantaneous E.M.F. of the machine is compensated by a potentiometer, equality being indicated by the absence of noise in a telephone receiver. E. E. F.

1921. *Cadmium Standard Cells.* **J. Henderson.** (Phil. Mag. 48. pp. 152–156, July, 1899.)—The author investigates how far reliance may be placed in cells constructed from "pure" materials, though not specially purified; also the effect of using moist crystals in place of solution, and acid salts instead

of neutral salts. "Crystal" cells were found to be satisfactory, but not those containing solution. The author concludes that the cadmium cell is superior to the Clark cell. The effect of ordinary impurities is small, except free acid. It does not matter whether acid or neutral salts are employed. The mean temperature coefficient was found to be 0·005 per cent. per 1° C. Sudden variation of temperature should be avoided on account of time-lag. Depolarisation is rapid. W. R. C.

1922. *Magnetic Properties of Inorganic Compounds.* **S. Meyer.** (Wied. Annalen, 69. 1. pp. 236–263, September, 1899.)—The author has extended his magnetic researches to some 200 inorganic compounds of all the known elements. From the material thus accumulated he draws some important conclusions. The combination of two diamagnetic elements is always itself diamagnetic. Certain apparent exceptions are due to impurities. Compounds consisting of paramagnetic elements are not, however, necessarily paramagnetic. Thus the oxides of magnesium, aluminium, tungsten, thorium, and silicon are diamagnetic, and this cannot be explained by impurities. In any case it is not permissible to infer the magnetism of an atom from that of the molecule it helps to constitute. Polonium and radium are paramagnetic. The author has discovered quite a series of strongly magnetic elements, represented by the symbols, Pr, Nd, Yb, Sa, Gd, and Er. The last of these, erbium, shows in the form of the oxide a magnetic permeability four times that of Fe_2O_3. If the metal is more strongly magnetic in the same proportion as its oxide, a very important addition to our magnetic resources will have been made. As a rule, the molecular magnetism of paramagnetic compounds is smaller than the sum of the atomic magnetisms. In diamagnetic compounds the magnetism is simply additive. The author admits that valuable conclusions may be drawn from the magnetism of an element as to its molecular weight, and he expects that the molecular weights of radium and polonium will be found to be somewhere about 180, or above 230. E. E. F.

1923. *Magnetic Field within a Tubular Current.* **W. de Nikolaieve.** (Comptes Rendus, 129. pp. 202–203, July 24, 1899.)—Experiment shows that a magnetic pole placed within a tubular current experiences a magnetic couple. A. D.

1924. *Magnetic Properties of Hematite.* **A. Abt.** (Wied. Annalen, 68. 4. pp. 658–673, August, 1899.)—The hematite was derived from the neighbourhood of the great deposit of magnetite

at Vaskö, Moravitza. Rough preliminary measurements revealed the fact that similar pieces of magnetite and hæmatite, subjected to the same magnetising current, gave deflections of the magnetometer standing in the ratio of 4 to 1. More detailed measurements showed that both the maximum magnetisation and the remanent magnetism of hematite depend largely upon the structure of the ore. One particularly homogeneous specimen, showing a percentage of iron rather in excess of that indicated by the formula Fe_2O_3, exhibited a remanent magnetism approaching that of magnetic iron ore within some 70 per cent. The maximum magnetic moments of three equal prisms, of pyrrhotite, hematite, and magnetite respectively, were found to be in the ratio of 1 to 2·356 to 3·237.

Pyrrhotite shows the smallest magnetisation in comparison with its percentage of metallic iron. In hematite, as in steel and in magnetite, the intensity of magnetisation increases with the length of the rod. E. E. F.

1925. *Hysteresis at Low Temperatures.* **A. H. Ford.** (Elect. World and Engineer, 34. p. 195, August 5, 1899.)—A sample of transformer iron was tested for hysteresis with a Ewing hysteresis tester at the ordinary temperature of the room. It was then plunged into a beaker of liquid air, allowed to cool, quickly removed, and tested while cold. Finally, another test was taken when the iron had attained the ordinary temperature. Four samples of the same kind of iron were examined in this way, and the mean results, giving the hysteresis loss in ergs per cycle per cubic cm., at the density of one gauss, were as follows:—

		% Increase.
Initial	0·00124	
Cold	0·00159	28
After warming	0·00139	12

Some other samples of the same kind of iron showed the following effect of heat treatment:—

		Hysteresis Loss.
Annealed from	835° C.	0·0014
Quenched in water from	225° C.	0·00125
Quenched in water from	400° C.	0·00145
Quenched in water from	804° C.	0·00150

A. H.

1926. *Normal Curve of Magnetisation of Iron.* **W. S. Franklin** and **S. S. Clarke.** (Phys. Rev. 8. pp. 304–309, 1899.)—It is likely that there are three distinct magnetising forces holding each other in equilibrium in a specimen of magnetised iron, viz.:—

(*a*) The impressed magnetising force including the demagnetising force due to the free magnetic poles of the specimen.

(*b*) A coercive or hysteretic magnetising or demagnetising force due to magnetic lag as the specimen is brought from one magnetic state to another.

(*c*) A demagnetising force due to a store of recoverable potential energy in the iron, or rather to a store of magnetic energy which is not yet dissipated by hysteresis. Thus, if V is the amount of this undissipated magnetic energy per unit volume, then V is a function of B, and $\frac{dV}{dB}$ is the demagnetising force due to V.

The function V may be determined indirectly by determining the curve of magnetisation under conditions in which the coercive or hysteretic force is obliterated, for, in this case the impressed magnetising force H and the demagnetising force $\frac{dV}{dB}$ are at each step in equilibrium, so that the curve of B and H obtained becomes the curve of B and $\frac{dV}{dB}$. This curve the authors call the *normal curve of magnetisation.*

Two methods are employed for the obliteration of the coercive force in the determination of $\frac{dV}{dB}$. In one method the iron specimen is subjected to the process of demagnetisation by reversals at each step. In the other method the iron specimen, which is in the form of a wire, is stretched by a constant force and set into violent longitudinal vibrations before each set of readings of B and H. For large impressed magnetising forces the operation of demagnetisation by reversals does not entirely obliterate coercive force.

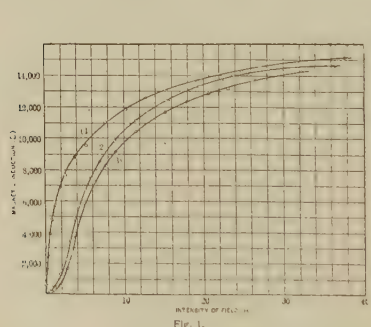


Fig. 1.

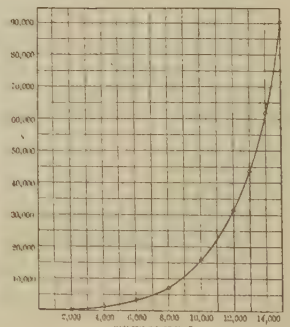
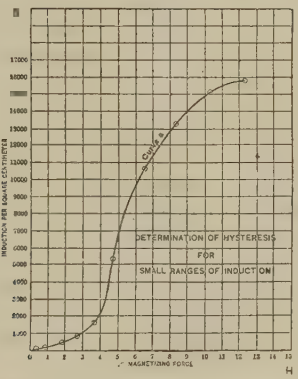


Fig. 2.

In the figures curve 1 gives the results obtained when at each step the specimen is subjected to the operation of demagnetisation by reversals. Curve 2 gives the results when subjected to violent longitudinal vibrations. Curve 3 gives the results when the specimen was magnetised in the ordinary way from a neutral

condition. The curve in figure 2 gives the values of the energy function V for various values of B as determined by integrating the curve 1. W. G. R.

1927. *Hysteresis Loss for Small Induction.* **H. S. Webb.** (Phys. Rev. 8. pp. 310–314, 1899.)—The method used for determining the hysteresis loss is due to W. S. Franklin, and consists in weighing by a balance the force necessary to reverse



the magnetism in the iron. The energy per cubic centimeter lost in the iron in one cycle is equal to the force measured by the balance in dynes divided by the area of the iron specimen.

The results obtained are embodied in curves, one of which is reproduced. W. G. R.

1928. *Magnetism and Molecular Rotation.* **Kelvin.** (Phil. Mag. 48. pp. 236–239, August, 1899.)—The author, in the light of Zeeman's experiments, renounces the old tempting gyrostatic hypothesis on the ground that no simplifying suppositions as to the character of the molecule, such as symmetry of forces and moments of inertia round the axis of the ring, can possibly give Zeeman's normal result of the splitting of a bright line into two sharp lines circularly polarised in opposite directions, when viewed parallel to the lines of force. Lorentz's theory, as expressed in Zeeman's first paper, he regards as essentially true. But he develops a novel conception of the magnetic molecule which goes some way towards accounting for the phenomena of diamagnetism. Each molecule is figured as an endless tube of non-conducting matter, "vitreously" electrified, and filled with an incompressible non-conducting fluid charged with an equal quantity of "resinous" electricity. In a magnetic field the fluid and the tube will experience equal and opposite tangential forces, and the tube will give rise to ether waves, while the fluid will

rotate and continue rotating as long as the field is constant. This rotation, however, constitutes kinetic energy, and hence the field will contain more energy where it is strong than where it is feeble, and the molecules will crowd towards the feebler portions of the field. E. E. F.

1929. *Magnetic Transformation-point of Nickel Alloys.* **L. Dumas.** (Comptes Rendus, 129, pp. 42–45, July 3, 1899.)—Alloys of nickel with carbon, silicium, manganese, and chromium are examined with respect to their magnetic permanence and non-permanence at the three selected temperatures 15° C. – 78° C. and –188° C. The results are tabulated in a form giving the constitution of each nickel alloy, and a qualitative statement as to whether its magnetisation at those temperatures is permanent, non-permanent, strong, feeble, or zero. Having regard to the constitution of the alloys, it is seen that the point of transformation from permanence to non-permanence depends not only upon the proportion of nickel, but also upon the temperature. The point of transformation can be lowered by the addition of carbon or manganese. Certain steels having more than 24 per cent. of nickel are non-permanent at low temperatures, others acquire permanence at low temperatures. One of these alloys is marked "permanent" at 15° C. "non-permanent" at –78° C. and again "permanent" at – 188° C. Carbon clearly preponderates in the power of bringing about this kind of change, especially when combined with chromium. R. A.

1930. *Magnetic Pyrites.* **G. Sagnac.** (Paris, Soc. Franc. Phys. Bull. 131. pp. 4–5, 1899.)—Apparatus described, devised by M. Weiss, for showing that magnetic pyrites has two rectangular directions, of which one is magnetic, the other not. (See also 1899, Abstract No. 713.) A. D.

1931. *Magnetism and the Thermoelectric Properties of Bismuth and its Alloys.* **G. Spadavecchia.** (N. Cimento, 9. pp. 432–446, June, 1899.)—Variations in the thermoelectric E.M.F. of the alloys of bismuth and tin under the influence of a magnetic field increase with increase of the variations in that field, and have different values according to the direction of the magnetisation. Under the influence of a given magnetic field the variations of the thermoelectric E.M.F. diminish from pure bismuth to an alloy containing 0·113 per cent. of tin, changing sign between 0·056 per cent. and 0·113 per cent.; then the variations increase up to 0·237 per cent., changing sign between this and 2 per cent. The sign changes again for an alloy between 80 and 83 per cent. of tin. A. D.

1932. *Comparison of Magnetic Instruments.* **L. Palazzo.** (Roma R. Accad. Lincei Atti, 8. pp. 386–392 and 443–447, 1899.)—This is the report of the Italian Commissioner who carried out a comparison of the instruments used in the magnetic survey of Italy with those of Parc Saint-Maur and Kew. The following are the differences in the readings, as observed when simultaneous readings were taken with the instruments in question :—

	Rome—Parc Saint-Maur.	Rome—Kew.
Declination	$+0'\cdot6$	$-0'\cdot7$
Dip	$-1'\cdot2$	$-0'\cdot7$
Horizontal Force...	$-0\cdot00009$	$-0\cdot00006$

E. E. F.

1933. *Magnetometer Observations and Atmospheric Pressure.* **G. Bellagamba.** (Roma R. Accad. Lincei Atti, 8. pp. 529–534, June, 1899.)—The time of vibration of a suspended magnet depends to some extent on the barometric pressure, as is proved by putting the magnet in an air-tight box, and varying the pressure by means of a pump. The variations, proportionately greater with a light than with a heavy magnet, are so small as to be negligible in determinations of the horizontal intensity of the earth's magnetic field. A. Gs.

1934. *Magnetic Elements of Potsdam.* **M. Eschenhagen.** (Wied. Annalen, 68. 4. pp. 917–918, August, 1899.)—The mean values for 1898 were computed from the hourly values of all days. They are as follows :—

	1898.	Difference : 1898–1897.
Declination	$10°\ 5'\cdot0$ W.	$-4'\cdot7$
Horizontal Force	0·18794 c.g.s.	+0·00019 c.g.s.
Vertical Force	0·43408 c.g.s.	+0·00010 c.g.s.
Dip	$66°\ 35'\cdot3$ N.	$-1'\cdot0$
Total Force	0·47302 c.g.s.	+0·00016 c.g.s.

Pronounced disturbances were observed on March 15th and 16th, and September 9th, and minor ones on fourteen other days. The disturbances show an increase over last year. E. E. F.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

1935. *Transition-Points.* **H. Le Chatelier.** (Comptes Rendus, 129. pp. 497–499, September 25, 1899.)—The author states that the existence of fixed transition-points and fixed tensions of dissociation are more a matter of theory than of experiment, and points out that the phase rule cannot be applied directly to infinitesimal quantities of substance where the internal pressure on a particle, due to surface tension, depends largely on the magnitude of the particle. T. M. L.

1936. *Electrical Reaction-Velocity.* **E. Cohen.** (Zeitschr. Elektrochem. 6. pp. 85–87, July 27, 1899.)—If two elements are placed in circuit, each with one electrode reversible as to the anion, and the other electrode reversible as to the cation, and differing only in that the electrolytic salt-solution is saturated with regard to the stable form of the salt in one element, but with regard to a metastable form in the other, the resultant (differential) E.M.F. of the combination affords an electrical measure of the maximal energy liberated in the change from the metastable to the stable form of the salt. Thus in the case of two Clark elements, one saturated with regard to the salt $ZnSO_4 . 7 H_2O$, and the other with regard to the salt $ZnSO_4 . 6 H_2O$, there is a difference of E.M.F. which increases from 0 at $+39°$ C. to 16·2 millivolts at $-5°$ (Jäeger, Wied. Ann. 63. 345, 1897). The velocity of change is proportional to the current $C = E/\Sigma R$. The author has shown (Zeit. Phys. Chem. 1899, 28. 723) that the resistance of a Clark cell is proportional to that of a saturated solution of zinc sulphate at the same temperature, and therefore for two cells of equal dimensions $C = E/k\ (\omega_1 + \omega_2)$, where ω_1 ω_2 are the specific resistances of a zinc sulphate solution saturated with regard to the salts $ZnSO_4 . 7H_2O$ and $ZnSO_4 . 6H_2O$. At the transition-point, 39° C., both salts are equally soluble and $\omega_1 = \omega_2 = 0{\cdot}0237$; below the transition-point the salt $ZnSO_4 . 7H_2O$ is less soluble, and ω_1 increases steadily to 0·0491 at $-5°$, whilst ω_2 increases to 0·0577. The electrical velocity-constant is $C' = E/(\omega_1 + \omega_2)$, and when calculated from this formula is found to rise from 0 at 39° to a maximum value $C' = 167{\cdot}6$ at 9°, and then to decrease to $C' = 151{\cdot}7$ at $-5°$. The occurrence of a maximum velocity of change is in accordance with the similar observations of Tammann (Zeit. Phys. Chem. 23. 326, 1888), on the velocity of crystallisation of supercooled liquids. T. M. L.

1937. *Electrical Determination of Saturation-Point of Solutions.* **J. H. van't Hoff.** (Zeitschr. Elektrochem. 6. p. 57–61, July 20, 1899.)—In this paper, read before the annual meeting of the German Electrochemical Society, the author describes a method, based upon the experiments of Dawson and Chiacaviglio, for determining the saturation-point of solutions of two or more salts, such as magnesium chloride and magnesium sulphate, with the corresponding sodium and potassium salts. The disadvantage of the usual specific gravity method of determining this point is, that the variation of specific gravity is slight for considerable difference of composition; and under certain conditions the specific gravity determination leads to incorrect conclusions as to the relative percentage of salts in solution.

The new method consists in measuring the electrical resistance of the solution, at intervals, between two fixed platinum electrodes. This method gives a much wider range of variation for mixed salt solutions of varying degrees of saturation, but is not free from the objection that at times solutions of different composition give the same electrical resistance. The author is now experimenting with a modification of the method in which the difference of potential between a mercury anode and calcium kathode is taken. Drawings of the apparatus used are given.

J. B. C. K.

1938. *Hydrolysis of Stannic Chloride.* **W. Foster, Jr.** (Phys. Rev. 9. pp. 41–56, July, 1899.)—The conductivity of solutions of stannic chloride in water is found to increase with time, becoming constant in fairly dilute solutions at values approximately the same as that of equivalent HCl solutions, whence complete hydrolysis is inferred. The change is rapid at high dilutions (complete in two or three hours), and slower at medium concentration, but strong solutions are already constant before they can be measured. The molecular depression of freezing-point found by Loomis agrees with the above assumption.

B. B. T.

1939. *Influence of Pressure on Formation of Tachydrite.* ($CaCl_2 . 2\,MgCl_2 . 12\,H_2O$.) **J. H. van't Hoff** and **H. M. Dawson.** (Berlin Akad. Sitzber. 30. pp. 557–562, June 15, 1899.)—This investigation forms one of a series of researches which are being carried out with a view to explaining the formation of the Stassfurt salt deposits. The influence of pressure on the nature of the deposited salts has been here investigated, and for this purpose tachydrite ($CaCl_2 . 2\,MgCl_2 . 12\,H_2O$) was specially chosen, since it is formed from its components at the very convenient temperature of 22° C.

The temperature of formation of tachydrite under atmospheric pressure has been determined very accurately by the thermometric

method, two experiments giving respectively 22·4 and 22·399° C. The influence of pressure was measured in the manokryometer, in which the pressure on the system is attained by means of the expansion accompanying the formation of tachydrite from its components, the result being a state of equilibrium between the tachydrite and the partially transformed $MgCl_2 . 6 H_2O$ and $CaCl_2 . 6 H_2O$. After a dilatometric determination of the temperature of formation under atmospheric pressure by working with the open manokryometer, the latter was closed, the temperature of the bath raised, and the pressure corresponding to the condition of equilibrium at this temperature was determined by reading off the volume occupied by the enclosed air column. The mean result is that the temperature of formation of tachydrite is raised 0·017° C. by an increase of pressure equal to 1 atmosphere.

The authors point out that, from thermodynamical considerations, the influence of pressure on the formation of other minerals occurring in the Stassfurt deposits must be of the same order of magnitude; and that, in comparison with the influence of temperature, the pressure exerts but little effect on the crystallisation which results in the formation of oceanic salt deposits. Assuming a maximum pressure of 180 atmospheres, the effect of the latter in the case of tachydrite corresponds to a variation in the temperature of only 3° C. J. B. H.

1940. *Dissociation and Dielectric Constants.* **H. Euler.** (Zeitschr. Phys. Chem. 28. pp. 619–628, 1899.)—Polymerised bodies possess as a rule high dielectric constants. A case is quoted in which the molecular conductivity of a salt diminishes as dilution increases, and the author attempts to show that the dissociating force increases with the number of ions in the solution. E. E. F.

1941. *Electrolytic Evolution of Hydrogen.* **A. Coehn.** (Zeitschr. Elektrochem. 6. pp. 37–41, July 13, 1899.)—The electromotive force necessary to electrolyse water so as to cause bubbles of gas to be given off must exceed a certain minimum, this minimum depending on the metal of the electrodes. Caspari has carried out an investigation on this subject, the results of which have not yet been published, but Coehn gives here a few of them.

The E.M.F.s measured between the cathode of the metal and a constant hydrogen electrode, when bubbles of hydrogen are beginning to form, are as follows:—

Pt (platinised)...	0·005	Pd.....	0·48
Au	0·02	Sn.....	0·53
Pt (ordinary) ...	0·09	Pb.....	0·64
Ag	0·15	Zn.....	0·70
Cu	0·23	Hg	0·78

Were the evolution of hydrogen a reversible phenomenon these numbers would in every case be zero, while the difference of potential between the hydrogen electrode and the anode would be 1·08 volts. It is evident that with platinised platinum the condition of reversibility is practically fulfilled.

Coehn has already given an expression for the condition that hydrogen bubbles should be evolved in the case when the action is reversible. He now introduces into this expression another factor for the above excess E.M.F. which prevents reversibility, and in the expression so modified he considers the effects produced by varying the various factors, such as concentration of the ions of H, or the ions of the metal in salt solutions, the osmotic pressure, &c. He illustrates by means of the formula the different ways of preventing the solution of zinc in sulphuric acid solution :—By diluting the acid ; by amalgamating the zinc ; by introducing $ZnSO_4$. He also illustrates the fact that lead can be deposited electrolytically from an acid solution, while zinc cannot be so deposited.

The particular property of the metal on which he considers the excess E.M.F. depends is the solubility of hydrogen in the metal.

Ostwald, in his discussion, attributes the excess E.M.F. entirely to the surface of the metal, and is led to this conclusion by the fact that with liquid electrodes the same value of this excess E.M.F. is obtained with amalgams of Zn, Cd, &c. as with pure Hg. If electrolysis is carried on very slowly, he considers a continuous state of things may be kept up by diffusion without any hydrogen bubbles being liberated at the kathode. If, however, bubbles are to be liberated, a certain extra amount of work will be required to supply the energy necessary to create the first small bubble. Assuming the first bubble to have infinitesimal dimensions, an infinite pressure would be required, and infinite supersaturation. Assuming molecular dimensions only, the necessary supersaturation is beyond all known limits, but the potential comes out less than that experimentally determined for Hg.

Ostwald thinks that velocity must enter into the question, and that different values of the potential necessary to form the first bubble would be obtained with different time limits. It is possible that the H, which has been separated out as ions, has no charge at first, and that the reaction $2H = H_2$ in the dissolved state takes some time. Then this single atom H would have greater solubility in the liquid and a much smaller super-pressure of solution or super-saturation would be necessary to give the same potential.

Bredig attributes the phenomenon to combination of the H with the metal of the kathode similar to the combination of a Na kathion with the metal of the kathode which he proved to occur with heavy current densities. J. B. H.

1942. *Electrolysis away from Electrodes.* **F. T. Trouton.** (Electrician, 43. p. 294, June 23, 1899.)—Two beakers, one placed within the other, contain the electrolyte, and one electrode is placed in each. The inner beaker is perforated with a small hole, so that the arrangement practically forms a Caldwell interrupter. When a current passes at a minimum pressure of 800 volts continuous, or 500 volts alternating, a blue glow appears, and oxygen and hydrogen are evolved at the hole. The continuous currents varied between 0·3 and 0·08 ampere. The oxygen always appeared in the inner beaker, no matter what the direction of the current. W. R. C.

1943. *Organic Electrolysis by Alternating Currents.* **M. Krüger.** (Elektrochem. Ztschr. 6. pp. 29–32, 1899.)—This is a short summary of the work of Drechsel and Gerbes on the effect of alternate-current electrolysis on ammonium carbamate, and that of the former author on its effect on certain other organic solutions, with a hypothetical explanation of the action. W. G. M.

1944. *Electrolysis of Platinum Chloride.* **W. Dittenberger and R. Dietz.** (Wied. Annalen, 68. 4. pp. 853–859, August, 1899.)—The authors tested Kohlrausch's supposition that platinum chloride in solution takes the form H_2PtCl_4O, and that during electrolysis it splits up into the ions H_2 and $PtCl_4O$, the metal thus going to the anode. They consider it more probable that chloroplatinic acid is formed (which possesses a much higher conductivity than fresh platinum chloride solution) according to the formula, $2\ H_2PtCl_4O = H_2PtCl_6 + PtCl_2O + H_2O$. Stannic chloride also shows an anomalous behaviour of this kind, a small amount of tin being conveyed to the anode.
E. E. F.

1945. *Electrolysis of Hydrochloric Acid.* **D. Tommasi.** (Elect. Rev. 45. pp. 469–470, September 22, 1899.)—Electrolysing hydrochloric acid with currents at 1·02, 1·42, and 2·04 volts, the author observed that the platinum anode is dissolved only in concentrated HCl of density 1·2. Diluted acids yielded oxides of chlorine, about which no particulars are stated. H. B.

1946. *Electrolysis of Alkali Chloride Solutions.* **Foerster.** (Zeitschr. Elektrochem. 6. pp. 11–26, July 6, 1899.)—In this paper, read before the annual meeting of the German Electrochemical Society, Foerster reviews the experimental work of

Fogh, Oettel, Haber, Wohlwill (see 1899, Abstract No. 341), Winteler (see 1899, Abstract No. 1407), and Muller (see 1899, Abstract No. 1408), and discusses the results obtained by them in their relation to those obtained by Jorre and himself. The paper is unsuited for useful abstraction; but Foerster thus summarises the bearing of these researches upon the industrial utilisation of electrolysis for chlorate production :—

1. The reduction at the kathode should be minimised as far as possible, either by formation of a skin of calcium hydrate or by the use of potassium chromate. (See Muller's researches.)

2. The electrolyte should be slightly acid, in order that free hypochlorous acid may be produced.

3. A large volume of electrolyte should be used, and it should be constantly agitated, in order to promote those secondary reactions requiring time for their completion.

4. A temperature of at least 40° C. should be maintained—to promote the secondary reactions named above, to reduce the necessary E.M.F. for a given current density, and to minimise the formation of perchlorates.

In closing his paper, Foerster stated that the ideal process for chlorate production should reach the efficiency attained in the electrolysis of a solution of pure calcium chloride, with which current efficiencies of 87 per cent. could be constantly maintained. It is possible that in time the efficiency obtained on an industrial scale will approach this figure. J. B. C. K.

1947. *Position of Industrial Electro-Chemistry.* **W. Borchers.** (Zeitschr. Elektrochem. 6. pp. 61–80, July 20, 1899.)—This paper was prepared for the last annual meeting of the German Society of Electrochemists, in response to a request made by the Committee to Dr. Borchers at the meeting of 1898. It contains a statement of the power utilised and available at every electrochemical or electrometallurgical works now in existence, together with the names of the owners and of the engineers who supplied the plant and machinery; but as the information in Dr. Borchers' possession is incomplete, there are many gaps in the table in which this information is gathered together.

A diagram showing the extent to which electricity is used in the production of the more important metals or non-metals, and tables showing the estimated weight and value of this output, are also given in the original paper. The remaining portion of the paper discusses the current efficiency of the Hall and of the Heroult aluminium extraction processes, as revealed by the outputs of the works using these processes, and the possibilities of aluminium and of calcium carbide as energy carriers.

J. B. C. K.

1948. *Electrical Bleaching.* **V. Engelhardt.** (Elektrochem. Ztschr. 6. pp. 28–29, 1899; also Oesterr. Chemiker-Zeitung, Wien, 1898, 13.)—O. Prelinger, in the bleach-works of F. Gebauer in Charlottenburg, has obtained practical results on a large scale with a Kellner electrolytic cell attached to a tank, maintained at 20°–25° C. by a cooling worm (to prevent the formation of chlorates), and provided with a centrifugal pump and circulating pipes of hard lead. When 650 litres of sodium chloride solution of 10° Bé (110 kg. NaCl per cb. m.) were thus circulated for three hours with a current of 114 amp. and 112 volts (=19 H.P. hrs.) passing, the solution finally contained 0·85 per cent. active chlorine, or 5·5 kg. of active chlorine in the whole solution. Reckoning the price of salt at 96 kr. per 100 kg., and that of power at 1·41 fl. per 100 H.P. hrs., and taking the amortisation of the plant (at 10 per cent.) as 48 kr., the cost of the whole operation was 1·90 fl., which is equivalent to 36 kr. per kilogramme of chlorine. In a comparative experiment on 33,800 m. (2,800 kg.) of light cotton cloth, the electrolytic bleach (with 2·81 grm. of available chlorine per litre) and subsequent treatment with hydrochloric acid cost 2·52 fl., whilst a chloride of lime bleach cost 8·34 fl. In another experiment on the same scale the relative costs were 5·07 and 12·63 fl.

W. G. M.

1949. *Electrolytic Ozone.* **E. Andreoli.** (Électricien, 18. pp. 145–147, September 2, 1899.)—This article is a history of the early attempts to make ozone by the electrolysis of solutions, usually of an acid. Schoenbein is cited as the earliest worker in this field and the results he obtained are given. Soret in 1854 showed that the temperature of the solution had a marked effect on the amount of ozone formed, and his own and other figures are quoted, while the theories of Lupke, Le Blanc, Berthelot &c., are discussed. Finally, the author points out that Rhumkoff's coil has entirely superseded the electrolytic method, and that there is in fact no more recent patent for the latter than that of Donovan in 1860. The author asks whether the electrolytic method might not now be utilised in some special cases to advantage, considering the immense improvements that have been made in all the apparatus &c., for such work.

J. L. F. V.

1950. *High-Temperatures by means of Aluminium.* **H. Goldschmidt.** (Zeitschr. Elektrochem. 6. pp. 53–57, July 20, 1899.)—In this paper, read before the annual meeting of the German Electrochemical Society, the author reports upon the technical utilisation of his process for obtaining high temperatures by means of powdered aluminium. The details of this process

were described in a previous paper before the Society. The applications of the method are three :—

1. The production of metals and alloys. Manganese, chromium, various alloys of these two metals, ferro-titanium and ferro-boron are being produced at Essen by a company called the "Chemische Thermo-Industrie," and the industrial utilisation of the process is about to occur in France.

2. The production of artificial corrundum. This by-product of the reduction of metallic oxides by powdered aluminium is finding a ready sale for various purposes.

3. The production of heat for metal-working operations. The method is being used for hardening, for hard soldering, for welding, and other operations. The localisation of the heat is an important characteristic of the process. Its use for rail-bonding by welding on electric tram-lines, has been successfully initiated at Essen.

Defective parts in steel-castings can be made good by this method. J. B. C. K.

1951. *Magnetic Ore Separators.* **H. C. McNeill.** (Electrician 43. pp. 639–640, August 25th, and pp. 674–675, September 1, 1899. Abstract of paper read before the Iron and Steel Institute.) —A description is given of the following systems for the magnetic concentration of ores: Wenström, Monarch, Dellvik-Gröndal, Heberle, and Wetherill. W. R. C.

GENERAL ELECTRICAL ENGINEERING.

1952. *Iron-Consuming Batteries.* **J. Waterhouse.** (Soc. Chem. Ind. Journ. 18. pp. 559–560, June, 1899.)—An account of using iron instead of zinc in Daniell cells. No trouble occurred through deposits of basic iron. W. R. C.

1953. *Germain's Primary Battery.* (Écl. Électr. 19. pp. 422–424, June 17, 1899.)—This battery, which has come largely into use, is a form of Leclanché in which the electrolyte is retained between the plates by cellulose. Curves of discharge are given. W. R. C.

1954. *Aron Energy-meter with Automatic Rewinding.* **J. Reyval.** (Écl. Électr. 19. pp. 377–384, June 10, 1899.)—The chief defects of the old type of Aron meter were the necessity of periodical winding, of careful adjustment of the pendulums to synchronism in position, and the want of automatic starting of the pendulums. All these defects, with others, are removed in the new model, which has been accepted as accurate by the Austrian Government. The theory of the instrument is worked out [there is a misprint in a formula on page 379], and it is shown that in the old type the relative gain or loss of the pendulums was sensibly proportional to the energy consumed in the circuit. In the new pattern the pendulums are short, and vibrate so much faster than the long ones formerly used that a considerable error would be caused with the same method of control; this is eliminated by causing the current to act on both pendulums, so that while one gains the other loses with regard to the normal rate. The disturbing terms in the equations then vanish, while the error due to external magnetic fields is also minimised. The mechanism is described in detail, with numerous illustrations. As the synchronism of the short pendulums cannot be perfect, nor the magnetic reactions made identical in both cases, the resulting errors have to be neutralised by simultaneously reversing the direction of rotation of the clockwork and the current in the shunt coils, at intervals of about twenty minutes. The devices by which this is accomplished are minutely explained, as well as the self-winding mechanism, which consists of an electromagnet actuating a pawl and ratchet at intervals. There are two sets of differential gear, one for the driving and the other for the integrating device. The method of connecting the meter with the circuit is also described. Additional advantages claimed for this meter are permanence of standardisation, as there are no steel magnets; freedom from thermal, frictional, and magnetic

errors; starting on very small loads; low consumption of power (1·8 watts in a 1,000 watt meter); and accuracy of records with alternating as well as direct current, no matter what the frequency or phase difference. A. H. A.

1955. *Long-Schattner Supply Meter.* (Electrician, 43. pp. 155–156, 1899.) (See 1899, Abstract No. 603.)—The amount of copper deposited is measured by a weight which slides on a beam graduated in watt hours for any prearranged voltage of supply. Drop of volts on 100-volt meter is 0·7 at full load, viz., 10 amperes. A $CuSO_4$ solution of 1·080 specific gravity is employed, *i.e.*, with 1 per cent. sulphuric acid and 99 per cent. water. Accuracy within 2 per cent. at 1 to 10 amperes and 4 per cent. at 0·15 ampere. M. O'G.

1956. *Lightning and Lightning Arresters.* **H. E. Raymond.** (Amer. Electn. 11. pp. 214–215 and 262–263, June, 1899.)—Leyden jar experiments seem to show that (1) the lower the voltage the smaller the effect of resistance upon the discharge; (2) the greater the capacity the less is the discharge affected by resistance; (3) the shorter the resistance for a given cross section the less its influence; (4) the discharge will be affected by any reactance to quite a considerable extent.

In the action of arresters on the line we note, first, that the discharge is opposed by considerable length of resistance, and but little by amount of resistance in ohms in shorter lengths; second, that the length of gap determines the striking-point of the arrester; third, that the inductance of the line introduces a favourable factor; fourth, that the capacity of the discharges affects the striking-point, in that for a given distance the greater the capacity the lower the striking tension; fifth, that reactance coils offer but little impedance to lightning discharges, and a considerable opposition to Leyden jar sparks; sixth, that the voltage of line discharge is much less than that of the Leyden jar, with a long gap in series with its circuit.

Considering the line as a condenser alternately charged by the atmospheric disturbances and discharging to earth at certain conditions of electrostatic unbalancing or dielectric strain, there are the following differences between this condenser and its action and the Leyden condensers and their action: the line is presumably of higher capacity, and certainly of greater self-induction; the lightning discharges are of much lower frequency, as is shown by the slight effect of a reactance coil upon them. These points explain the fact that an arrester with a short gap and a moderate resistance in series will take a line discharge in preference to one without resistance and with a longer gap. [See Abstracts Nos. 1387, 1389 (1898), and No. 605 (1899).] W. G. R.

1957. *Lightning Arresters.* **Bochet.** (Soc. Int. Elect. Bull. 16. pp. 184–207, 1899.)—This paper gives an illustrated description of various lightning arresters for the protection of electric lines, and contains also a discussion of the conditions which arresters should satisfy. W. G. R.

1958. *Fuse-wires for Air-lines.* **J. Mattausch.** (Zeitschr. Elektrotechn. Wien, 17. pp. 159–160, 1899.)—In localities where danger is likely to occur to aerial lines, owing to stray currents from other circuits or to lightning, it is proposed to introduce fuses into every span of wire. The fuses are arranged so that the line-wires exert no strain upon the fuse-wire; and when a fuse "blows," the line-wires are still upheld. To get this result an insulating shackle is introduced into each span to take the strain, and fuse-wire is used to establish electrical connection between the ends of the shackle. Various modifications are described. R. A.

1959. *Concentric Wiring.* **M. O'Gorman.** (Elect. World and Engineer, 34. pp. 228–231, August 12, 1899.)—A defence of this system is given—it does not affect telegraphs or the ship's compass. Leakage current, shocks, or fires are impossible; the quantity of copper and rubber in cables is diminished; lamps can be screwed into the same sockets as fittings if the latter break down. Concentric flexibles are smooth externally, and being at zero potential attract no dust. Switchboards are waterproof and cheap because single pole. A special method of testing cables is given. E. H. C.-H.

1960. *Electricity in Coal-Mines.* **H. N. Gardner.** (Amer. Electn. 11. pp. 373–375, August, 1899.)—This article deals chiefly with the various conditions to be met in designing electrical machinery for mining work, the chief of which are rough usage and dirt; some practical notes on the methods adopted are given. A. H. A.

1961. *Electrically Driven Workshop of the A. E. G.* (Electrician, 43. pp. 437–440, July 21, 1899.)—Up to 2·000 H.P. is absorbed by the three-phase electric plant of the Allgemeine Elektricitäts-Gesellschaft. The astonishing development of this factory is traced, and the electrically driven lathes and tools illustrated. A plan and elevation of the works is given. M. O'G.

1962. *Modern Workshop Practice.* **F. Bathurst.** (Elect. Rev. 45. pp. 275–279, August 18th, and pp. 299–303, August 25, 1899.)—A detailed description, with numerous illustrations, of the machine tools and methods in use in the workshops of E. Kolben and Co. A. H. A.

1963. *Electrical Machinery on Board Ship.* **A. Siemens.** (Electrician, 43. p. 815, September 29, 1899. Paper read before the British Association, 1899.)—The chief advantage of electric power on shipboard is the absence of clumsy and leaky pipes. The difficulty is the variations in the loads on auxiliary machinery. The strain on a winch often stops it. In such cases, shunt-wound motors driving through friction clutches are used, or else series-wound motors with a special cut-out arranged to break the main circuit on occasion and only allow a certain current to flow through a by-pass circuit. The author mentions an electric steering gear and rudder indicator as an example of the first method. E. H. C.-H.

1964. *Automatic Pressure Regulator.* (Electrician, 43. p. 573, August 11, 1899.)—The "Chapman" regulator for automatically varying the resistance in the shunt circuit of dynamos is described and illustrated. There are two solenoids, one of which is subjected to the potential difference to be regulated, and controls the other; the latter actuates a multiple-point resistance switch in series with the exciting circuit. The instrument can be compounded to give a rising pressure with increase of load, and can be applied to alternators as well as dynamos. A. H. A.

1965. *Thawing Water-Pipes with Electricity.* (Canad. Elect. News, 9. pp. 57–58, 1899.)—Frozen water service pipes are thawed by means of alternating currents passed through the pipes themselves. A pressure of 20 to 50 volts is used, obtained from a portable transformer connected with the street mains; a current of 200 to 400 amperes is passed through the frozen pipe until the water flows freely, which usually takes place in a few minutes. Details of actual cases are given. A. H. A.

1966. *Electric Engraving Machine.* **F. J. Patten.** (Elect. World and Engineer, 34. pp. 306–307, August 26, 1899.)—The electric pantograph described in Abstract No. 1824 (1899) is here applied to the process of engraving upon wood or metal. Instead of merely tracing the picture as in the pantograph, the stylus is arranged to cut or engrave the lines to any desired depth. R. A.

1967. *Wool Removed from Skins Electrically.* (Electrician, 43. p. 333, June 30, 1899.)—This is a description of an electrical knife made of a platinum iridium wire rendered incandescent by a current of about 60 amperes at 4 volts. W. G. R.

1968. *Portable Electric Drilling Machine.* (Elect. World and Engineer, 34. p. 105, July 15, 1899.)—This is a description of a drill driven by an electric motor with a 50 per cent. speed regulation, and manufactured by the Stow Company, of Binghamton, N.Y. W. G. R.

1969. *Electric Power in Steel-Making.* **E. B. Clark.** (Cassier, 15. pp. 441–455, 1899.)—A paper written in popular style, giving an account of the application of electric power to machines used in steel-making, *e.g.*, charging and drawing machines, gantry cranes, locomotive cranes, drills, punches, shears, and electromagnets for handling plates. The paper is accompanied by numerous photographic illustrations. A. S.

1970. *Installation of Steam Boilers.* (Elect. Rev. 44. pp. 973, 1010–1012, 1056–1057, 45. pp. 124–126, 177–178, 376–377, 426–428, 505–506, 735–736, 1899.)—An illustrated series of articles on the construction and erection of steam boilers.

EDITOR.

1971. *Simple Steam Engine with Remarkable Economy.* (Amer. Electn. 11. p. 208, 1899.)—The steam engine designed by Elihu Thompson for steam automobile work has four cylinders each $2\frac{1}{2}$ in. diameter and 3 in. stroke, all single acting and worked single expansion, the output of the four being about 5 H.P. The economy obtained with this small engine reached $20\frac{1}{2}$ lbs. of water per H.P. hour, the steam pressure being between 160 and 200 lbs. with a considerable degree of superheating, the engine at times being worked with the steam-pipe red-hot. The steam is admitted to the cylinder by a simple poppet-valve, and expands until the piston uncovers the exhaust ports. The conditions are such that there is no retraversing of any of the passages by the steam. The steam is always moving in one direction, so that there are no inter-actions to cause waste of energy. A. S.

1972. *Electric Light and Traction Engines.* (Elect. Rev. 44. pp. 980–982, June 16th; 1069–1070, June 30th; 45. p. 24, July 7, 1899.)—A series of articles on the general design of steam engines for electric light and traction power stations.

EDITOR.

GENERATORS, MOTORS, AND TRANSFORMERS.

1973. *Over-Compounding Dynamos.* **E. K. Scott.** (Elect. Rev. 45. pp. 428–429, September 15, 1899.)—The author describes a method of compensating for the curvature of the B–H curve by shunting the series coils with iron wire; as the load increases the resistance of the iron increases with rise of temperature more rapidly than that of the copper coils, thereby shunting a smaller proportion of the total current. It is remarked that over-compounding, by increasing the magnetic flux, tends to reduce sparking at the brushes. The common practice of specifying that dynamos for electricity works shall be designed for 460 volts for lighting, but shall be able to work at 550 volts for traction, is criticised on the score that the weak field in the former case conduces to sparking and involves increased first cost.

A. H. A.

1974. *Regulation of Alternating Current Generators.* **C. L. Cory.** (Journal of Electricity, 8. pp. 33–40, August, 1899. Paper read before the Pacific Coast Electric Transmission Association, San Francisco, June 20–21, 1899.)—The chief item affecting the regulation of alternators is the power factor of its load, since a load of low power factor means large wattless demagnetising current in the armature of the machine. W. G. R.

1975. *Crocker-Wheeler Motors for Special Purposes.* (Elect. World and Engineer, 34. pp. 140–141, July 22, 1899.)—The paper describes, among others, a motor specially designed for driving machinery which has to be stopped with precision. One pole-piece is hinged and forced away from the armature by a strong spring which at the same time tightens a band brake on a brake drum attached to the armature spider. When the field is excited the movable pole-piece is pulled toward the armature and the band brake released. The spring and brake band may be adjusted so that the armature is stopped and held firmly the instant the current is cut off, or it may be allowed to make a few revolutions before stopping. R. B. R.

1976. *Theory of Induction Motors.* **J. Heubach.** (Elektrotechn. Ztschr. 20. pp. 301–305 and 314–317, 1899.)—The first part of the paper is devoted to polyphase motors. Considering the field of the stator, the author remarks that the intensity of the field undergoes, in general, fluctuations consequent on the fluctuations in the inducing ampere-turns. He considers the two

extreme cases in which the ampere-turns have (*a*) a maximum and (*b*) a minimum value, and draws diagrams (consisting of zigzag lines) illustrating roughly the distribution of the field in these two cases for a two-phase and a three-phase motor in which each side of a stator coil is distributed over three tunnels in the stator core. Next comes the calculation of the counter E.M.F. in the stator: this is determined by supposing the stator coils displaced, step by step, in a stationary field which resembles the rotating field of the motor, calculating the instantaneous values of the E.M.F. corresponding to each small displacement until a complete half-wave has been traced out, and then finding its R.M.S. value. The actual rotating field, is, however, a pulsating one; in applying the method just described for finding the E.M.F., the author overcomes the difficulty by considering the two cases (*a*) and (*b*) separately, and supposing that in each case the rotating field remains constant. The result of this investigation shows that the R.M.S. value of the E.M.F. is the *same* in each case, notwithstanding the fact that in case (*a*) the maximum field-intensity is higher. From this it follows that the total flux from a pole is not a constant quantity. The torque is next calculated on the supposition that the actual field of the motor is replaced by an equivalent sine field. The calculation of the torque involves the introduction of certain constants depending on the rotor winding and the breadth of its coils. The results obtained are applied to Heyland's diagram for the induction motor (Elektrotechn. Ztschr. 1896). The second part of the paper deals with the single-phase motor. The results obtained for polyphase motors may be applied to the single-phase motor by supposing the latter replaced by two equal and mechanically coupled polyphase motors whose inducing windings are connected in series in such a manner as to produce oppositely rotating fields. By this artifice the diagram of the single-phase motor may be deduced from the corresponding two diagrams of the equivalent pair of polyphase motors. The calculation of the primary field, primary counter-E.M.F., and of the torque, proceeds on the same lines as those already indicated for the polyphase motor. The paper contains valuable tables of the coefficients for different kinds of windings which are required in motor calculations, and the practical value of which has been tested by the author.

A. H.

POWER DISTRIBUTION, TRACTION, AND LIGHTING.

1977. *The Feeder System at Boston, U.S.A.* (Railway World, 8. pp. 237–244, July, 1899.)—The mileage operated is over 300 miles of single track, and the cables used comprise 510 miles of feeders and 70 miles of insulated return wires. The sections of copper were calculated from the following formula :—

$$S = \frac{1{\cdot}5\ PAMG^2}{V^2\ (G-1)}$$

where—

S = cross section of feeder in circular mils.
P = power delivered to cars in watts, nominal.
A = specific resistance of copper per mile-mil.
M = distance to centre of load, miles.
V = pressure at power station in volts.
1·5 = a constant representing the ratio between total drop and feeder drop.
G = economical constant which may have any value between 1 and 2 and is determined by one of the following formulæ :—

For overhead lines—

$$G = 1 + \sqrt{\frac{2{\cdot}25\ M^2A\ (CD + E_oF_o)}{2{\cdot}25\ M^2A\ (CD + E_oF_o) + V^2\ (H\ I\ 8760 + JK)}}$$ or

For underground lines—

$$G = 1 + \sqrt{\frac{2{\cdot}25\ M^2A\ (CD + E_uF_u)}{2{\cdot}25\ M^2A\ (CD + E_uF_u) + V^2\ (H\ I\ 8760 + JK)}}$$

where—

C = cost of copper in dollars per mile-mil (copper only, and does not include cost of insulation and installing).
D = interest and depreciation on above amount.
E_o = cost of insulating and installing copper overhead per mile-mil.
E_u = cost of insulating and installing copper underground per mile-mil.
F_o = interest and depreciation on above amount for overhead lines.
F_u = interest and depreciation on above amount for underground lines.
H = time factor of energy lost in feeder.
I = cost of producing this energy per watt hour.

J = cost of generating plant per watt installed.
K = interest and depreciation on plant.

The average insulation resistance of the underground cable ranges from 200 to 1,500 megs. per mile. E. H. C.-H.

1978. *Electricity Works of Small Output.* **A. D. Adams.** (Amer. Electn. 11. pp. 263–264, June, 1899.)—The author discusses the problem of electric lighting for comparatively small towns generating their own electrical energy, and gives a comparison of the direct and alternating systems for such a purpose. W. G. R.

1979. *Plymouth Electricity Works.* (Elect. Engin. 24. pp. 102–110, July 28th, and pp. 146–149, August 4, 1899.)—These articles contain a full illustrated description of the Plymouth combined lighting and traction works. The lighting plant is 2,000 volts alternating and the traction plant 500 volts continuous current. One engine carries a dynamo and an alternator on the same shaft in order to deal economically with light loads. The coal arrangements are very complete, and the whole cargo of a 600-ton ship can be discharged in two days. Lancashire boilers without cross-tubes are used, worked at 130 lb. pressure, but constructed for 160 lb. to avoid reduction in working pressure as the boilers age. Instead of being individually lagged, a non-conducting floor has been formed over the battery of boilers. The motors of the electric 3-throw pumps are arranged with two totally distinct circuits to their armatures, so that they can be economically run at 730 r.p.m. when the two circuits are in parallel, or at 365 r.p.m. when in series. The feed and steam pipe arrangements have received particular attention. A ring steam main has been avoided. E. H. C.-H.

1980. *Potteries Electric Tramways.* (Railway World, 8. pp. 203–212, June, 1899.)—This system will comprise 35 miles of tramway on a 4-feet gauge. Current at 500 volts will be supplied to the whole system from two stations. The drop in the return circuit will be kept down by negative boosters. A full description is given of the power station at Stoke-on-Trent.

E. H. C.-H.

1981. *Bommern-Witten Tramway.* **M. Schiemann.** (Elektrotechn. Ztschr. 20. pp. 507–510, July 20, 1899.)—This is an illustrated description (9 figures) of a typical German electric tramway which has been equipped by the firm of O. L. Kummer

and Co. of Dresden. The power station has steam-driven sets—150 lbs. steam, 135 revs. per minute, eight-pole dynamos—and there is also a buffer battery of accumulators. Three very clear diagrams of connections are given. The first shows the series parallel and brake connections of the motors at various points of the controller; the second is a car-wiring diagram; and the third gives the switchboard diagram arranged for four dynamos, the battery, and ten feeder circuits.

The station arrester described is a modified form of the Thomson circuit breaker, the curved horns of the latter being replaced by two carbon blocks — one adjustable — which are held on the ends of two steel cores which pass down the interior of the blow-out coil. E. K. S.

1982. *Electric Traction.* **A. D. Greatorex.** (Electrician, 43. pp. 627–629, August 25th; 676–677, September 1st; and 702–704, September 8, 1899.)—Abstract of a paper read before the Incorporated Association of Municipal Engineers, giving a brief description of the various systems of traction—overhead, conduit, accumulator, and combined—with estimates of their cost. E. H. C.-H.

1983. *Electric Traction Statistics as Data for Design.* **A. Hecker.** (Elektrotechn. Ztschr. 20. pp. 590–592, August 17, 1899.)—The author, after carefully investigating available statistics, finds that if abnormal cases be excepted, there are definite relations connecting the number of inhabitants with the gross receipts and the number of car-miles run. These relations may be expressed by the following formulæ :—

$$y_1 = 2{\cdot}5 \times 1{\cdot}12^{\frac{x_1}{4} - 1}$$

where y_1 denotes the receipts per head per year, in shillings, and x_1 the number of inhabitants divided by 10,000. Further—

$$y_2 = 10 \times 1{\cdot}08^{\frac{x_1}{4} - 1}$$

y_2 denoting the number of car-miles per year per inhabitant. A. H.

1984. *Controlling Stray Currents on Electric Railroads.* (Elektrotechn. Ztschr. 20. pp. 427–429, June 15, 1899.)—This is the discussion on a paper read by **M. Kallmann** before the Elektrotechn. Verein, Berlin (see 1899, Abstract No. 1301). **Wagner** pointed out the very small loss in weight (100 grms.

and 205 grms.) of the two earth plates in the generating station at Spandau after 2½ years' running. **West** described a method of determining the resistance of rail joints by a Wheatstone Bridge test between three equidistant insulated axles of a special truck. **Kallmann** discussed the effect of joints on rail resistance, and described a laboratory experiment illustrating leakage currents, the methods of testing, and the effect of distance between feeding-points. **Glaisberg** pointed out that the electrolytic corrosion by stray currents depends on the absolute value of such currents and the distance between the feeding-points, which should therefore be made the basis of the regulations with regard to leakage, instead of the percentage leakage as specified by the English Board of Trade. L. B.

1985. *Indispensable Accessories of Electric Traction.* **H. E. P. Cottrell.** (Elect. Rev. 44. pp. 667–670, 711–713, and pp. 755–758, 1899.)—These, the first three of twelve fully illustrated articles on the above subject, deal with trucks. (pp. 843–846, 923–925, June 9, and 1051–1053, June 30, 1899): Brakes. (45. pp. 88–91, July 21, 1899): Roller bearings, life-guards, gongs, track-scrapers, sand-boxes, heaters. (pp. 211–214, August 4, 1899): Heaters and lighting. (pp. 260–262, August 18, 1899): Lighting couplings, commutator segments, brushes, circuit breakers, lightning arresters. (pp. 303–305, August 25, 1899): Trolleys, couplings. (pp. 349–351, September 1, 386–387, September 8, and 424–426, September 15, 1899): Bonding and welding. E. H. C.-H.

1986. *Overhead Line Material for Electric Railways.* **Benz.** (Elektrotechn. Ztschr. 20. pp. 493–498, July 13, 1899.)—A detailed description of trolley wire insulators, strain insulators, cross-wire suspension insulators, pull-over brackets, frogs, joints, &c., as made by the Allgemeine Elektricitäts-Gesellschaft of Berlin. Stabilit, a vulcanised fibre material, is used for the insulation, and the author gives its resistance after being kept in a damp atmosphere for four weeks at 8·5 megohms per cubic centimetre.

The article is illustrated by 48 figures, of which ten are line drawings in section. E. K. S.

1987. *Overhead Line Construction.* **A. B. Herrick.** (Street Rly. Journ. 15. pp. 277–281, 437–440, July, 513–515, August, 1899.)—Articles descriptive of the construction in detail of overhead trolley lines, including the proportioning of feeders.

EDITOR.

1988. *Rail-Bonding.* **R. D. Appleton.** (Railway World, 8. pp. 269–270, July, 1899. Paper read before the Railway and Electrical Association of Virginia, U.S.A.)—Bonds of solid copper become loose owing to expansion. Flexible bonds break off. Electric welding decarbonises the ends of the rails and results in two thumps per joint instead of the usual one. Cast welds are good mechanically, but their resistance is high, and gets higher with time. The ideal bond must absolutely prevent corrosion of contact surfaces by excluding water in spite of all variations of temperature. It must be able to give and take as much as an eighth of an inch per joint again and again without breaking or crystallising. It should be capable of carrying as much current as the rail itself. The author has in three years' experience found these qualities in the plastic bond. E. H. C.-H.

1989. *Electric Rail Welding.* (Elect. World and Engineer, 34. pp. 234–235, August 12, 1899.)—This is a short description of the electric rail welding plant of the Lorain Steel Company, Ohio, as employed in making 7,500 rail joints in the Buffalo street railway system. The trolley wire current is transformed by a rotary converter carried on the car into single-phase current of 300 volts, and then down to 5 or 7 volts by a static transformer of one secondary turn giving up to 25,000 amps. The joint is made by means of fishplates welded on to either side of the web under heavy pressure. Each joint takes fifteen minutes to complete. L. B.

1990. *Brake Shoes.* (Street Rly. Rev. 9. pp. 477–480, July, 1899.)—This paper gives an account of patents on brake shoes for the last thirty years, of tests prior to 1895, and a summary of the most recent experiments. A table showing the mean coefficients of friction is given, having been prepared from the data published in the Master Car Builders' Proceedings, from the Reports of Tests made for the Sargent Company, Chicago, and from the Reports of Tests by Goss of Purdue University. The tests were made at initial speeds of 65, 40, and 30 miles per hour respectively; and two diagrams are given showing the mean coefficient of friction, and the distance run before stopping on the assumption that each shoe has to absorb the energy of a mass of 12,000 lbs. As a rule, the coefficient of friction is less at the high speeds; the total variation over the experiments recorded being from 11 to 39 per cent. The effects of the various brake shoes on a chilled wheel and on a steel-tired wheel are recorded. A. S.

1991. *Thermal Tests for Car Wheels.* (Street Rly. Rev. 9. pp. 486–487, July, 1899.)—Goss and Smart of Purdue University

have made some experiments for the Griffin Wheel Company, of Chicago, on thermal tests of wheels, and the heating to which a car wheel will be subjected in service. The wheel specifications of the Pennsylvania Railroad Company provide for a thermal test by pouring a ring of cast iron 1½ inches by 4 inches in section around the tread of the wheel, the pouring being made from one point on the circumference, and the ring being removed two minutes after pouring. In the tests made at Purdue a soft cast iron brake shoe was applied with a pressure of 2,800 lb., and the wheel driven for twenty minutes at a peripheral speed of 30 miles an hour. At the end of the test an examination showed that sulphur, which had previously been inserted in a hole 3 inches from the tread, had melted (240° F.), while no part of the wheel more than 2 inches from the tread was hot enough to melt tin (440° F.). A second wheel was run for five minutes at 50 miles an hour with a brake pressure of nearly 3,000 lb. At the end of the five minutes the conditions were so severe as to threaten the destruction of the shoe, and the test was stopped. Sulphur was not melted at a distance greater than 2 inches from the tread. The Pennsylvania thermal test was applied to similar wheels, and the results showed that the rise in temperature was most rapid in that side next to the pouring, and slowest at a point diametrically opposite.

A third series of tests were made in which the channel provided for the molten iron had different dimensions from those called for in the Pennsylvania specifications, the molten iron being poured into the mould from two points diametrically opposite. The maximum temperature of a point 3 inches from the tread was 440° F., and the time required to reach a temperature of 240° F. was 5·75 times as great as in the brake test. From these tests the conclusion is drawn that the Pennsylvania thermal test is much too severe, and the modification of the specifications as in the third series of the Purdue tests would amply provide for safety. A. S.

1992. *Diatto Surface Contact System.* J. Blondin. (Écl. Électr. 19. pp. 121–130, 1899.)—About 2 km. of line at Tours are equipped with Diatto's electromagnetic system. Under each contact-plate is a box containing a magnetic plunger, the top of which makes (carbon) contact with the surface-plate when drawn up, while the lower end travels in a mercury cup connected to the feeder. The car carries electromagnets specially arranged. An alarm contact behind the car rings a bell if a section remains alive. E. H. C.-H.

1993. *W. R. Smith's Overhead Conduit System.* (Railway World, 8. pp. 266–268, July, 1899.)—The conduit is a small tube of papier maché, suspended horizontally 22 feet above

the street by $\frac{1}{16}$ inch steel wires hung from a 1 inch wire rope supported on poles 100 yards apart. Current is taken from two copper rails supported on insulators within the conduit. A small truck with four flanged wheels runs on the rails within the conduit, being kept in contact by a roller and spring. This truck is drawn along by conductor cords, which are reeved over a pair of tackle falls on the car to pay out and in at a uniform tension, to allow for the lateral movement of flangeless wheeled vehicles on ordinary roads. At points a short length of the conduit before the branch is hinged and is swung from one line to the other by the motor man pressing a button in the circuit of one of two electromagnets. The claims for this system are: (1) It costs 48 per cent. less than the trolley system to convert an existing tramway from horse haulage to electric traction. (2) It costs 10 per cent. less than the trolley system to lay a new line. (3) Freedom from all electrolysis. (4) There is no wear upon the supporting wires, and no lateral strain upon the supporting pillars. (5) Tramway rails may be dispensed with where the traffic is light or the rails inconvenient. (6) The points and crossings of the conduit are on one level. E. H. C.-H.

1994. *Combined Electric and Petrol Motor Car.* **É. Hospitalier.** (Ind. Élect. 8. pp. 316–319, July 25, 1899.)—The Pieper Company have brought out a car which is normally propelled solely by an oil engine, but on hilly ground is helped by an electric motor. The oil engine works at a constant rate, and when the vehicle does not absorb all the engine's power the excess drives the motor as a dynamo and charges the accumulators. As the accumulators only have to supply power occasionally, they are kept fully charged, and can therefore (as was clearly shown at the French Automobile Club cell trials) safely give rates of discharge which would seriously damage them if the cells were only partially charged. The engine having always to work at constant speed and load, a simple carburetter is used, adjusted once for all. The engine is direct coupled to the dynamo-motor, which is shunt wound, and is used to start up the engine. The rate of charging can be adjusted by field-regulation. Changes of speed are effected mechanically. The engine gives 2,500 watts, and the motor about 1,800, so that on hills nearly 5,000 watts can be obtained. The battery of 40 cells weighs 125 kg. complete, and can give up to 20 watts per kg. of total weight. Backward motion is obtained by shutting off the carburetted air from the engine and reversing the current in the armature of the motor. The three-passenger vehicle complete, without live weight, weighs 600 kg., and runs up to 30 km. per hour. It will take 12 per cent. grades at 12 km. per hour. The author predicts that the "petro-accumobile" will be the cab of the future. E. H. C.-H.

TELEGRAPHY AND TELEPHONY.

1995. *Mercadier's Multiplex Telegraphy.* (Elektrotechn. Ztschr. 20. pp. 305–307, 318–320, and 336–337, 1899.)—This system was described in the Annales Télégraphiques in 1891. It consists in "tuning" a set of telephones so that each responds to an alternate current of one, and only one, periodicity. These so-called "monotelephones" may be connected in series, one at each station, and any particular station can be signalled to by an alternating current of the appropriate periodicity. The present articles describe the arrangement of circuits and apparatus, and the author gives his reasons for believing that this system is more economical than those which have preceded it. R. A.

1996. *Wireless Telegraphy.* **J. J. Green.** (Amer. Electn. 11. pp. 344–346, July, 1899.)—Elementary description with photographs of apparatus. A failure to communicate across Chicago is ascribed to the direct line between the tops of the vertical wires being intercepted by telegraph wires. M. O'G.

1997. *Selector System of Circuits.* **E. Bernard.** (Elect. Rev. N.Y. 34. pp. 225–227, 1899.)—This is a translation in English of the article by J. Voisenat on the Bandot system of telegraphy. (See 1898, Abstract No. 1300.) R. A.

1998. *Telephone Exchanges.* **B. von Wehrenalp.** (Zeitschr. Elektrotechn, Wien. 17. pp. 331–340, June 14, 1899.)—A detailed description, with coloured charts, of the new system of telephone exchanges at Vienna. R. A.

1999. *Private Central Telephone Stations.* **Mandroux.** (Électricien, 15. pp. 122–125, 1898.)—Diagrams explaining "Monocord" systems as used by the French Government. (See 1898, Abstracts Nos. 462 and 463.) M. O'G.

2000. *Transmitter Working with 20 Volts.* **G. Dumont.** (Électricien, 17. pp. 305–308, 1899.)—By using a special granular material, in a modified box with receivers having an extended magnetic field, 20 volts can be used without producing harsh sounds, and with increased clearness on long lines. M. O'G.

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